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EURISCON '98
Third European Robotics, Intelligent Systems & Control Conference

SOFTCOM '98
IMACS/IFAC International Symposium on Soft Computing in Engineering Applications

General Chairman: **Professor Spyros G. Tzafestas**

June 22-25, 1998 • DIVANI CARAVEL Hotel • Athens • GREECE

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NTUA

SOFTCOM '98

IMACS/IFAC INTERNATIONAL SYMPOSIUM ON SOFT COMPUTING IN ENGINEERING APPLICATIONS

SIRES · MOBINET · IEEE GREEK CHAPTER

June 22-25, 1998
Divani Caravel Hotel
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Intelligent Robotics & Automation Laboratory (IRAL)
Department of Electrical and Computer Engineering
National Technical University of Athens (NTUA)

General Chairman

Spyros G. Tzafestas

Welcome to EURISCON '98 - SOFTCOM '98

It is my great pleasure to welcome you at the Third European Robotics, Intelligent Systems and Control Conference (EURISCON '98) and the IMACS / IFAC International Symposium on Soft Computing in Engineering Applications (SOFTCOM '98), Athens, Greece, 22-25 June 1998 . The venue of these two parallel conferences is DIVANI CARAVEL HOTEL, a beautifully positioned luxurious hotel in Central Athens nearby Acropolis / Parthenon, Lecabetus (Likavitos) Hill, Athens Museum, Athens Gallery, and other archaeological sites. The two previous EURISCON Conferences were held in June 1991 (Corfu, Greece) and August 1994 (Malaga, Spain).

In response to the ever-growing interest in the areas of intelligent systems, robotics, control and soft computing, 236 papers were submitted for EURISCON and 64 papers for SOFTCOM. After the careful evaluation by the members of the IPCs (three for each paper), 180 papers were accepted for EURISCON and 50 for SOFTCOM. The program involves seven Plenary Papers by eminent colleagues, and two Panel Discussions which will produce interesting debates.

I wish to express my sincere thanks to all organizations and institutions who are making this twin conference possible; to the authors of the papers for their high-level and innovative contributions; to the members of the Advisory and International Program Committees for their efforts in reviewing the papers; to the speakers of plenary sessions for accepting our invitation; to the members of the Local Organizing Committees for their intensive work; and to the sponsors and supporters for their involvement and contribution towards the success of the conferences. We are grateful to them all for their effort they have put in bringing together this interesting technical program, which I am certain all of you will enjoy .

I wish you a nice stay to sunny Greece, and I look forward to enjoying together with you the technical and social program.

Spyros G. Tzafestas
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Date	Time	Session	Hall	Chairpersons	
22/6	8.45 a.m.	**Opening Session**	AA	S.G. Tzafestas, P. Borne, R. Vichnevetsky	
	9.15 a.m.	**Plenary I**	AA	C. Houpis	A. Venetsanopoulos
	11.30 a.m.	**Plenary II**	AA	G. Schmidt	H. Adeli
	3.30 p.m.	**Euriscon 1**	A	A. Kanarachos	A. Liegeois
		Euriscon 2	B	G. Papakonstantinou	R. Araujo
		Euriscon 3	C	T. Kaczorek	R. Dekeyser
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	6.15 p.m.	**Euriscon 4**	A	T. Koussiouris	K. Galkowski
		Euriscon 5	B	S. Kollias	P. Maragos
		Euriscon 6 (I)	C	C. Spyropoulos	R. Basili (Italy)
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23/6	8.45 a.m.	**Euriscon 7**	A	K. Kyriakopoulos	N. Aspragathos
		Euriscon 8	B	D. Pham	P. Xirouchakis
		Euriscon 9 (I)	C	K. Watanabe	T. Jordanides
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		Euriscon 11	B	P. Paraskevopoulos	N. Koussoulas
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		Softcom 4	D	N. Panagiotacopulos	F. Matia
	3.30 p.m.	**Euriscon 13 (I)**	A	A. Venetsanopoulos	K. Plataniotis
		Euriscon 14	B	J. Kontos	N. Sgouros
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	6.15 p.m.	**Euriscon 16 (I)**	A	C. Houpis	M. Garcia Sanz
		Euriscon 17 (I)	B	T. Papazoglou	V. Petridis
		Euriscon 18 (I)	C	E. Blana	J. Bokor
		Softcom 6	D	J. Zaprianov	E. Skordalakis
24/6	9.00 a.m.	**Plenary III**	AA	Ph. Coiffet	K. Kosanke
	11.00 a.m.	**Panel I**	AA	S.G. Tzafestas	
	12.30 a.m.	**Panel II**	AA	A.N. Venetsanopoulos	
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		Euriscon 20	B	G. Kokkinakis	N. Hatziargyriou
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		Softcom 7	D	A.G. Bakirtzis	C.G. Looney
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		Euriscon 23	B	C. de Silva	N. Sigrimis
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		Euriscon 25	D	M. Nicolich	E. Dialynas
	8.30 p.m.	**Closing Session**	A		

The Technical and Social Program at a Glance

DIVANI CARAVEL Hotel: Halls AA, A, B, C, D

	SUNDAY 21 JUNE	MONDAY 22 JUNE	TUESDAY 23 JUNE	WEDNESDAY 24 JUNE
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8.45 a.m.		OPENING SESSION (AA)	Parallel Sessions EURISCON 7,8,9 SOFTCOM 3	
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9.15 a.m.		PLENARY I (AA) (Schmidt, Coiffet)		
10.30 a.m.				Coffee Break
11.00 a.m.		Coffee Break	Coffee Break	PANEL I (AA) (Trends in Intelligent Robotics)
11.30 a.m.		PLENARY II (AA) (Houpis, Kosanke, Vichnevetsky)	Parallel Sessions EURISCON 10,11,12 SOFTCOM 4	
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3.30 p.m.		Parallel Sessions EURISCON 1,2,3 SOFTCOM 1	Parallel Sessions EURISCON 13,14,15 SOFTCOM 5	
5.30 p.m.				Coffee Break
5.45 p.m.		Coffee Break	Coffee Break	
6.00 p.m.	Registration & Informal Meeting (DIVANI CARAVEL Hotel)			Parallel Sessions EURISCON 22,23,24,25
6.15 p.m.		Parallel Sessions EURISCON 4,5,6 SOFTCOM 2	Parallel Sessions EURISCON 16,17,18 SOFTCOM 6	
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PART 1

PLENARY PAPERS

From Industrial to Personal Robotics: Capabilities, Technologies and Applications

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Over the last two decades industrial robot manipulators and automatic guided vehicles (AGV) have developed into mature and well-established technologies with numerous applications in the manufacturing industries. More recently exploitation and fusion of well-proven technologies have led to a more flexible type of robots, the so-called service robots. Service robots often show a certain degree of autonomy. They are typically developed for specialized non-manufacturing applications, such as cleaning or construction. Service robots are at the beginning of a broader market introduction and various new products have become available more recently.

Personal robots can be considered an even more advanced class of robots with a higher degree of flexibility, mobility and autonomy. They donot only work for humans, they even work with or assist humans and share with users the same environment. Personal robots are still at an early stage of development. They pose many non-trivial technological, psychological and above all safety challenges to designers and users. Various market studies predict that there may be a rapidly growing demand for personal robots in the near future. Relevant application areas for personal robots are the health or home care sector, rehabilitation and entertainment.

The presentation will discuss a variety of state-of-the-art service robot products, explain their capabilities and examine current limitations and deficiencies. We will indicate the impact of real-time stereo vision and biped walking technology for the advancement of service and personal robots.

Based on experience with an advanced mobile manipulator developed in our laboratory [1], [2] we will outline key functionalities and enabling technologies for next generation personal robots. The focus of discussion will be on issues of

- environmental perception and object recognition,
- coordinated anthropomorphous motion (manipulation and locomotion) and

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dexterity,

- support of navigation by an intelligent building infrastructure,
- a multi-modal human-robot-interface,
- networking for remote monitoring and operation in the sense of telerobotics,
- a decentralized system architecture integrating functional expert modules for semi-autonomous robot operation.

The before-mentioned technological features and the resulting service capabilities will be demonstrated through experiments with the semi-autonomous personal robot ROMAN while operating in an extended home scenario.

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Trends in Robot Control. Autonomous Behavior and Remote Control. The VR Contribution.

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ABSTRACT: In the huge amount of litterature about robot control few papers precise the basic assumptions on which the contribution relies as connected to a robot definition and vocation. That point is not important when the commented control level is concerned with an improving of robustness or precision, and so on, for a mechanism, trajectories of which are known in advance. The problem becomes more conspicuous when it deals with the motions or behavior to be respected in order to perform a given task in an ill-known environment. So an introduction will be dedicated to the basic assumptions from which behavior autonomy demands to be studied.

In a next section, the various ways covering all robotic researches will be presented allowing to guess the different ideas people developped believing to approach either a behavior autonomy or a good remote mastering of robots. Analyzing these approaches, a new possibility for autonomy can be examined that takes under consideration some forgotten features of environment. The way to go toward some self awareness will be exposed underlining the difficulties.

In teleoperation the two main traditional drawbacks preventing from an extensive use of such a system deal with a poor friendly using possibility from one hand and a not less poor information feedback quality from the slave site to the master one, from another hand. VR techniques can renew the teleoperation concept through the creation of a virtual universe, well adapted to man behavior from one side, and also well adapted to control machines from another side. VR world becomes a new adaptive and intelligent interface between the human operator and his real workplace. Difficulties and ways to overcome them will be discussed in both cases of a remote short distance and long distance control. The conclusion that can be proposed is the idea that a perfect teleoperation system must pass through some capacity of the controlled machine to be autonomous in some extent. The point deals with the level of autonomy that has to be aimed at. And the basic problem exposed at the beginning is once more again raised.

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BRIDGING THE GAP

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ABSTRACT

As an introduction to the main theme of this presentation, the author presents what he feels has occurred in some disciplines in academia. Especially in the graduate curricula. Since the early 50's, it is apparent that a shift of emphasis has occurred from a "true engineering curricula" to one that can be best described as an "engineering science curricula." Based upon the author's experience in the control system design area, a distinction is made between the scientific and engineering methods. This distinction is enhanced by the development of engineering rules to "bridging the gap" between these two methods. These engineering rules, based upon the control area, focus on achieving a successful "real-world" control system design. The design of control systems whose nonlinear characteristics are significant is addressed. A qualitative explanation of "structured plant parameter uncertainty" is presented. Some real-world control system designs will be highlighted. A design example is used to illustrate how the "real-world" knowledge of the plant to be controlled and the desired performance specifications can be utilized in trying to achieve a successful robust design for a nonlinear control problem. The design process is enhanced by the use of engineering rules. This presentation provides an overview of "using robust control system design to increase quality" in attempting to "bridge the gap" between control theory and the realities of a successful control system design.

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Building International Consensus on Enterprise Integration
(EP 21859: EI-IC)

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LONG ABSTRACT

1 Problem Statement

The advent of the global markets for goods, capital, technologies and last but not least information increases competition between enterprises and requires more efficient and effective business operations. Competitive advantages can be obtained by the use of new methodologies, technologies and adoption of best business practices. E.g. enterprise engineering and integration technologies (EEI) are capable of supporting the enterprise operation in its day-to-day decision making for all relevant activities from customer order acceptance and asset management to customer support.

However, a lack of business justification, a plethora of seemingly conflicting terminology and proposed solutions inhibit, or at least delays, the use of relevant methods and tools in the industry, especially in (SMEs[1]). Potential users are not really employing the research results and there is no sufficient interest of ICT[2] vendors to invest in the necessary support technology due to the envisioned small current markets.

In addition, awareness and acceptance of EEI technology in the user community is practically not existing. Therefore, there is an urgent need for an industry oriented promotion campaign with its focus on business and enterprise engineering and integration and aimed on the SME community in particular. Added value will be provided through consolidation of the state of the art and by increasing the international consensus on business and enterprise engineering and integration. The main goal of such an undertaking is to improve industry competitiveness, help to prepare the market for enterprise engineering and integration methods and technologies and thereby protect and enable exploitation of the large investment (MECUs[3]) made in relevant ESPRIT[4] activities an other activities, by both industry and taxpayers in many countries around the world.

1 Small & Medium Enterprises.
2 Information and Communication Technology.
3 European Strategic Programme for Research & Development in Information Technology.
4 Million European Currency Units.

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2 An Approach for Improvements

Enterprise engineering for enterprise integration will play an important role in the much needed improvements of enterprise operation. Its main objectives are to provide the right information, at the right time, at the right place and to enable a human-centric environment (remove organisational barriers). EEI tools will link decision makers on all organisational levels to relevant and real time information even across organisational boundaries. Such tools will enable new co-operation paradigms like extended and virtual enterprises to become reality on a broad scale and in the long run will support enterprise model based operation monitoring and control.

To overcome the barriers in application of enterprise engineering and integration technologies an international initiative has been started jointly by the Europe (ESPRIT) and the USA (National Institute of Standards and Technology - NIST).

The EI-IC Project has been established to increase international consensus on enterprise engineering and integration and to promote it in the industry with special focus on SMEs. Several workshops with international expert have been held on the research issues in enterprise engineering and integration and their results have been reported in the International Conference on Enterprise Integration and Modelling Methodologies (ICEIMT'97[5]). Additional workshops will be held in several regions of Europe to disseminate information to the industry. The conference identified barriers, proposed solutions, and communicated results, thereby helping to justify the technology to industry so that key technologies can be moved profitably from the international R&D domain to broadly based implementation.

Starting from the needs for enterprise engineering and integration and discussion of the state of the art the paper defines a base for building consensus on the EI issues. The GERAM[6] framework (developed by the IFAC/IFIP Task Force[1]) is proposed for identifying the position and the relations of the different ongoing research activities in the area of enterprise engineering and integration (EEI).

3 Enterprise Engineering and Integration: State of the Art and Standardisation

The state of the art in enterprise engineering and integration is rather confusing. On the one hand it claims to provide solutions for many of the requirements in enterprise engineering and integration. On the other hand those solutions seem to compete with each other, focus on particular issues, use conflicting terminology and do not provide any clues on their relations to solutions on other issues. Work has been carried out around the world on the main areas of enterprise engineering and integration over the last 30 years. A rather good overview has been provided in the proceedings of the two ICEIMT conferences held in 1992 [2] and 1997[3]. Special emphasis on Enterprise Modelling has been placed in reference [4]. Ref. [5] provides a survey of enterprise engineering and integration related architectures and methodologies, which compares several enterprise reference architecture with the results of the IFAC/IFIP Task Force and the European prestandard on enterprise modelling constructs [5]. For additional standardisation in the field see references [6-10].

5 International Conference on Enterprise Integration and Modelling Technology

6 Generalised Enterprise Reference Architecture and Methodology.

4 Enterprise Integration - International Consensus: Project Results

The ICEIMT'97 Conference has been the major event of the *Enterprise Integration - International Consensus (EI-IC)* initiative. It provided a forum for presentation of the project results. Special emphasis was on the results from the five ICEIMT workshops that preceded the conference which included a number of proposals for R&D projects. The emphasis of enterprise engineering and integration is on enterprise operation for any kind of enterprises, but with emphasis on the new organisation paradigms of extended, virtual and agile enterprises, which will become major contributors to the area of inter organisation electronic commerce.

From a technical viewpoint, integration of information and communication technologies (ICT) looks feasible today: Highly integrated prototypes and commercial solutions with limited integration capability through middleware, componentware and integration protocols are available. Research in ICT is moving in the direction of more interoperability of components and distributed control.

The following list identifies areas of work to be done in basic research, applied research and development, standardisation and last but not least activities to increase industrial awareness and acceptance for technology transfer:

4.1.1 Research

- *Role of humans in enterprise operations - human models*
- *Engineering of extended, virtual and agile enterprise organisations – theory of virtual enterprises*
- *Enterprise metrics and characterisation*
- *Formal semantics for business process representations*

4.1.2 Development

- *Tools for decision support in enterprise operation planning and execution*
- *Infrastructures to support interoperability across organisation boundaries*
- *Unified Enterprise Modelling Language (UEML) to enable common understanding and interoperability*

4.1.3 Standardisation

- *Standards for electronic commerce to support interoperability in extended and virtual enterprises*

4.1.4 Awareness and Acceptance

- *Dissemination of information on enterprise engineering and integration*
- *Education and training on enterprise engineering and integration*

The paper reports on the project methodologies and the results achieved in both areas – building the international consensus and promoting enterprise engineering and integration in the SME community.

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DIFFERENTIAL EQUATIONS AND COMPUTERS : A HISTORY OF CHANGE IN SCIENTIFIC RESEARCH.

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ABSTRACT : Today's demand for high performance scientific computing lists applications requiring the numerical solution of differential equations in prominent place. More than half of the "Grand Challenge Problems" presented a few years ago as a justification for developing super (parallel) computers with speeds in the 10^{12} operations per second range by the year 2000 fall in this category, including climate modeling , fluid turbulence , pollution dispersion and ocean circulation simulation. With hindsight, one may observe that much of the historical development of scientific computers and computing machinery was equally motivated with the desire to solve differential equations. Scientific computers had started with mechanical differential analyzers (in the 1930's), specialized airplane simulators (early 1930's), electronic analog computers (used until the 1960's), all of the above dedicated to soving differential equations. And finally came the electronic digital computers heralded by ENIAC (1940's) whose first objective was also the integration of differential equations : "ENIAC" stands for "Electronic Numerical Integrator and Computer", and the word "Integrator" was added to convince those in the US Government (who in 1942 were asked to fund the project) that this machine would integrate the differential equations of ballistics. Much of the current work is concerned with the developments of parallel (multi computer) configurations and the required parallel algorithms for large systems simulations. Increased reliability allows for spectacular calculations: some recent simulations that have been publicized have involved on the order of 100 processors computing in parallel for as long as several years.

The implications have been not only in terms of what is being accomplished. It has also changed the way scientific research is being done. The personal ability to deal with differential equations analytically was an important component in the practice of modeling new things from the physical world, with all the limitations that this implied, and those scientists that left a mark in the development of new fields were often those who had significant mathematical skills (beginning, of course, with Newton) Now that integration of differential equations (among other things) is done by machine (and another relevant factor is that research is now often much more a group activity that was the case half a century ago), much has changed in the relation between the human mind and the outside world in the development of the sciences.

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* President of IMACS

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Intelligent Signal Processing using Neural and Fuzzy Techniques

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I. ABSTRACT

The amount of research published to date indicates an increasing interest in the area of signal processing. In recent years, significant advances have been made in the development of signal processing techniques, especially for multichannel signals. Such techniques are used in a variety of tasks, such as color image filtering and processing of video sequences, seismic deconvolution for oil exploration, chaotic signals and boundary detection in vector fields.

The most common signal processing task is noise filtering. Filtering is the process of estimating a signal degraded, in most cases, by additive random noise. This task is an essential part of any signal processing system whether the final product is used for human interpretation, such as visual inspection or for automatic analysis. Several filtering techniques have been proposed over the years. Among them, are linear processing techniques, whose mathematical simplicity and the existence of a unifying theory make their design and implementation easy. Their simplicity, in addition to their satisfactory performance in a variety of practical applications, has made them methods of choice for many years. However, most of these techniques operate under the assumption that the signal is represented by a stationary model, and thus they try to optimize the parameters of a system suitable for such a model. But, many signal processing problems cannot be efficiently solved by using linear techniques.

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The need to deal with increasingly complex nonlinear systems coupled with the availability of increasing computing power has led to a re-evaluation of the conventional filtering methodologies. New algorithms and techniques which can take advantage of the increase in computing power and which can handle more realistic assumptions are needed. To this end, nonlinear signal processing techniques have been introduced more recently. Nonlinear techniqùes, theoretically, are able to suppress non-Gaussian and signal dependent noise, to preserve important signal elements, such as edges and fine details, and eliminate degradations occurring during signal formation or transmission through nonlinear channels. In spite of an impressive growth in the past two decades, coupled with new theoretical results, the new tools and emerging applications, nonlinear filtering techniques still lack a unifying theory that can encompass existing nonlinear processing techniques. Instead, each class of nonlinear operators possesses its own mathematical tools, which can provide reasonably good analysis of its performance.

As a consequence, a multitude of nonlinear signal processing techniques have appeared in the literature. At present the following classes of nonlinear processing techniques can be identified: (i) polynomial-based techniques, (ii) homomorphic techniques, (iii) order statistic-based techniques, (iv) techniques based on mathematical morphology, (v) neural network-based techniques, (vi) fuzzy-logic based techniques

Neural network-based techniques have been extensively used over the past ten years for multichannel signal processing. They have been successfully applied in signal processing and analysis, brain research, signal classification, speech recognition, and of course noise reduction. Their attractive generalization properties, their ability to perform complex mappings from a set of noise signals to the noise-free signal and their parallel implementation make them the method of choice in many digital signal processing applications. To demonstrate the effectiveness of the neural network based signal processing techniques, we consider in this paper the problem of time series classification. This problem arises in many real-world problems, such as speech identification, dynamic system identification, systems subject to failures/repairs, EEG diagnosis, piecewise linearization of nonlinear systems, target tracking and reconfigurable systems. An intelligent classification scheme has been devised to recursively identify the actual signal model which generates the time series by utilizing a bank of neural network-based predictors, each one trained off-line with labeled data from a particular source model.

In addition, to neural networks a number of techniques based on fuzzy logic principles have also been proposed for intelligent signal processing. In this paper, we examine the applicability of fuzzy logic techniques to the problem of color image filtering. Most of the fuzzy techniques in use today adopt a window-based rule-driven approach leading to data-dependent fuzzy filters, which are constructed by fuzzy rules in order to remove additive noise while preserving important signal characteristics, such as signal edges. Since the antecedents of fuzzy rules can be composed of several local characteristics, it is possible for the fuzzy filter to adapt to local data. Local correlation in the data is utilized by applying the fuzzy rules directly on the signal elements which lie within the operational window. Thus, the output of the fuzzy filter depends on the fuzzy rule and the defuzzification process, which combines the effects of the different rules into an output value.

ADROIT INTEGRATION OF SOFT COMPUTING, MATHEMATICAL OPTIMIZATION, AND PARALLEL PROCESSING FOR LARGE-SCALE ENGINEERING DESIGN AUTOMATION

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Automation of design of large one-of-a-kind engineering systems is a particularly challenging problem due partly to the open-ended nature of the problem and partly to the highly nonlinear constraints that can baffle optimization algorithms (Adeli, 1994). In this plenary lecture a multi-paradigm computing approach is presented for automating the complex process of engineering design through adroit integration of a novel neurocomputing model (Adeli and Hung, 1995), mathematical optimization (Adeli, 1994), and massively parallel computer architecture (Adeli, 1992a&b). The details of the algorithms and computational models are presented in a forthcoming book, Adeli and Park (1998).

Optimization of large and complex engineering systems is particularly challenging in terms of convergence, stability, and efficiency. Adeli and Park (1995) present a robust neural dynamics model for optimal design of structures by integrating the penalty function method, Lyapunov stability theorem, Kuhn-Tucker conditions, and the neural dynamics concept. Adeli and Park (1996) extend the neural dynamics model by creating a hybrid counterpropagation-neural dynamics model and a new neural network topology for optimization of large structures made of discrete sections subjected to the highly nonlinear constraints of commonly-used design codes such as the American Institute of Steel Construction (AISC) Allowable Stress Design (ASD) or Load and Resistance Factor Design (LRFD) specifications. The constrained structural optimization problem is formulated in terms of a neural dynamics model with constraint and variable layers. The counterpropagation (Hecht-Nielsen, R., 1987) part of the model consists of the competition and interpolation layers. The CPN network is trained to learn the relationship between the cross-sectional area and other properties of the cross section.

Park and Adeli (1997) present distributed nonlinear neural dynamics algorithms for discrete optimization of large steel structures. The algorithms are implemented on a distributed memory machine, CRAY T3D. In a distributed memory machine, a relatively large number of microprocessors are connected to their own locally distributed memories without any globally shared memory. For these machines, communications between the processors becomes a bottleneck because accessing memories of remote processors takes more time than accessing the shared memory in the shared memory machine. Thus, minimizing communications between the processors becomes an important consideration. Further, on distributed memory architecture, the limited local memory of each processor creates an obstacle that must be overcome through algorithmic restructuring. For the solution of resulting linear simultaneous

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equations a distributed preconditioned conjugate gradient algorithm is developed employing the worksharing programming paradigm.

The computational models are applied to minimum weight design of high-rise and superhighrise building structures of arbitrary size and configuration, including a 144-story superhighrise building structure with 20,096 members. The structure is subjected to dead, live, and multiple wind loading conditions applied in three different directions according to the Uniform Building Code (UBC). Optimization of such a large structure subjected to the highly nonlinear constraints of actual design codes such as the AISC LRFD code where nonlinear second order effects have to be taken into account has never been reported before. The patented computational model developed in this research finds the minimum weight design for this very large structure subjected to multiple dead, live, and wind loadings in different directions automatically. An attractive characteristic of the new neural dynamics model is its robustness and stability.

Acknowledgment

This presentation is based upon work sponsored by the U.S. *National Science Foundation* under Grant No. MSS-9222114, *American Iron and Steel Institute,* and *American Institute of Steel Construction.* H.S. Park has contributed to the project as a Research Associate. The methods and apparatus described in this presentation are currently the subject of a patent application by Hojjat Adeli and H.S. Park in the *U.S. Patent and Trademark Office*. A Notice of Allowance was received in August 1997.

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PART 2

EURISCON '98 ABSTRACTS

A Transmission Matrix for Robot Kinematics and Dynamics

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Abstract

Kinematics is still a large subject. In recent years new fields of interesting kinematics applications has emerged in different modern areas such as robots and manipulators, space mechanics, geology, animal locomotion, structural chemistry and surgery.

In this article we focus attention on a transformation matrix denoted Π which relates the linear and angular velocities of any two points of a rigid body rotating about an axis. Further the properties of this matrix are investigated. These properties seem to be useful for developing a new approach for solving direct and inverse problems in robotics.

The matrix Π is linear in the position parameters. Consequent position translations are equivalent to the product of corresponding Π-matrices. Further this transmission matrix is expressed in exponential form $\Pi = \exp(\Delta(\mathbf{P}))$, with the property $\Delta^2(\mathbf{P}) = 0$ which resembles that of the dual unit ε.

In the paper, these algebraic properties of Π and its use for the transmission of linear and angular accelerations as well as forces and torques is shown. Further the relation between Π and the link Jacobean is established. Some properties of Π that might be helpful for setting up new methods for solving robot inverse problems (inverse kinematics, inverse dynamics) are investigated.

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Parallel Platform Design and Kinematic Analysis using Evolution Strategy with Regeneration

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The first parallel mechanism shown up in 1979 by McCallion, was used in a robotics assembly cell, due to it's high precision characteristics, and high positioning accuracy. In recent years a lot of studies have been made in order to improve design of parallel manipulators and analyze their behavior.

Inverse and direct kinematics are the two problems concerning parallel manipulators. Analytical solutions for the workspace definition and trajectory design have been proposed but without taking into account physical constraints of the mechanism. Due to this disadvantage, optimization techniques become necessary in order to incorporate the system physical demands (spherical and revolute joints tolerances, minimum and maximum actuators lengths, etc.). In this paper the inverse kinematic model is studied in order to determine the lengths of parallel platforms actuators, so as to succeed desired positioning and orientation of the moving platform. All the system kinematic and design parameters are taken into consideration in the objective function which will be minimized. Due to the existence of local minima even the two membered Evolution Strategy (e.g. one parent and one offspring) fails to find the global minimum. This is demonstrated for three different types of parallel platforms (3DOF and 6DOF mechanisms) whose the results revealed, are getting «stack» at local minima.

Therefore a novel technique called «Evolution Strategy with Regeneration» has been developed so as to overcome the above problem, showing great improvement of the optimization performance. Stepping over local minima during the optimization procedure leads to the desired position and orientation of the moving platform while all kinematic and structural constraints are not violated. Results reveal that the two membered Evolution Strategy with Regeneration is an efficient method and works very well in a variety of parallel platform designs. The adaptability of the new method, makes design and kinematic analysis of parallel platforms feasible that take into account geometric constraints and physical system demands.

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The " l.i.p " Gymnastic Method with Two Arm Movements for link Parameter Identification (D ⊥ D || D Robot Type, Manutec R2)

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Abstract: In this paper a novel technique for robot parameters identification is introduced for a D ⊥ D || D robot type with revolute joints (Manutic R2) . We construct robot gymnastics with two arm movement. A corresponding set of dynamic parameters is selected such that the resulting dynamic equations are linear in these parameters. The constructed " l.i.p " gymnastics are chosen in a way that the resulting normal equations of parameter identification are well conditioned. The selected robot dynamic parameters are generally linear or quadratic functions of the physical link parameters. It is shown in the paper that the robot link parameters can be identified from " l.i.p " gymnastics with one or two link movements. With this " l.i.p " gymnastic techniques, not only the well known identifiable terms of inertia can be determined, but also the link mass m_k and the position of the center.of gravity r_k . The list of separately identifiable as well as the identifiable functions of link parameters for a revolt robot arm is given.

Key Words: Robot gymnastics, Parameter identification, Inverse dynamics.

H_∞ Robust Control System Design of a 3 DOF Robot Manipulator

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Abstract. This paper deals with the optimal H_∞ control problem design of a 3 DOF robot manipulator affected by actuators dynamics, sensor noise and non-modelling dynamics. The control objectives are to obtain a robust performance and robust stabilizing controlled system. In the design procedure, we derived a family of models of the plant based on a sinusoidal analysis of the frequency responses obtained for a finite number of arm configurations. From the Bode plots, we determined a multivariable nominal response and then, a nominal transfer function matrix was derived by applying a frequency multivariable identification algorithm (D. Bayard, 1997). By using the same multivariable frequency family responses, additive non-parametric uncertainty bounds were defined. This procedure to define uncertainty embrace the uncertainty due to inertia variations, which some authors consider to be the main source of uncertainty in a robot manipulator (I. Postlethwaite, 1991 and M. Spong, 1992). To guarantee stability robustness in the presence of this perturbations, weighting function were introduced to normalize the H_∞ norm of the uncertainty $\left\|W_i^{-1}\Delta_i\right\| < 1$. Also weighting functions that act on the reference signal, gravity effect disturbance, sensor noise and error signal that guarantee an exact tracking were designed. The computation of the H_∞ controller were found usign the Robust Control Toolbox of MATLAB, and finally the controller were applied to a non linear robot model, good and satisfactory results were obtained.

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"Smooth Sliding Mode Control of Robots with Joint Flexibility"

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Abstract

In the analysis of the robot dynamics frequently the rigidity of the links and joints is assumed as a prerequisite. This assumption makes easier the implementation of the control laws but some times it is too far from the reality.

The robot flexibility affects its performance. The control laws designed for rigid robots can not compensate the high compliance of the joints or links. A comparison for the performance of a compliant robot with two different controllers -one for rigid manipulators and one for flexible- presented in a study by Fouad and Shaheen [1]. They show that if the controller does not compensate the compliance of the robot then the performance of the robot is quite far from the desired one.

The compliance of commercial robots is concentrated mainly in the joints, therefore the compensation of the joint flexibility is a very interesting task in the control design of the industrial robots. Several control techniques have been proposed to compensate the low joint stiffness such as the feedback linearization and singular perturbation methods (see Canudas de Wit, Siciliano and Bastin [2]). In addition, the sliding control technique was used to encounter the joint flexibility of robot manipulators. Last years the researchers are concentrated on the combination of sliding and adaptive algorithms in order to control the manipulators with compliant joints. A similar technique will be used in the present paper.

The proposed control law includes a two-stage controller based on the measurements of the rotations and velocities of robot actuators and links. The smooth sliding controller will be formed using the angular position errors of links and actuators. An adaptive law determines the unknown characteristics of the links, of the actuators and of the joints. The user defines only the desired position of the links, while the desired position of the actuators is defined implicitly from the desired position of the links and the estimated terms using the adaptive law. In the present paper, control techniques developed for rigid robots - Slotine and Li [3] - will be applied to the robots with flexible joints. From the simulation experiments it can be concluded that the introduced

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smooth sliding controller provides response essentially without chattering and it can be easily implemented.
The stability of the system will be investigated via Lyapunov's direct method. Simulations will be done for low joint stiffness compared to the joint stiffness of the industrial robots, in order to demonstrate the effectiveness of the proposed controller. Th accuracy and the shape of the response will be studied and will be compared with previous similar work.

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Singular Pertubation Based Control of Flexible Joint Robots

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Abstract

Recent work in singular pertubation theory and two-time-scale methods has been directed toward modeling, analysis and design of nonlinear and highly complex systems. Actually singularly pertubed systems are multi-time scale systems, due to the existence of small *parasitic* parameters, like small time constants, masses, etc. In the case of Flexible Joint Robots, the two-time scale behavior arises from the existense of some degree of joint elasticity (for example in robots with elastic deformation of bearings and gear teeth), which has significant effects to the closed-loop control system.

In this paper, a singular pertubation-based adaptive controller is developed for a flexible joint robot with inertia parameter uncertainty, which does not require any restriction on the robot joint stifmess. The two-time scale behavior of the full-order robot system is first shown and fully examined. Under rather weak conditions a decomposition of the original full-order robot system into separate slow and fast subsystems is achieved. This decomposition reduces the analysis complexity for the controller design and the computational effort, especially in the case of adaptive control. The separate slow and fast control laws are designed properly for each subsystem and then combined into a composite control law for the original flexible joint robot system. Simulation results based on the full-order dynamical model of a two-link flexible joint robot are included and demonstrate the superiority of the tracking performance.

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Response Optimization of a Non Linear Controlled Flexible Robot Arm Carrying a Variable Mass

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ABSTRACT

The response of a robot system consisting of a flexible arm, carrying a variable concentrated mass at its end, is optimized. The system is driven by a closed, particularly non linear, control loop of a rotating drive with hysteresis which is mounted on the opposite arm end. This driver receives only three discrete commands, determining its angular velocity by a non linear saturation filter with dead zone. The system feedback is related to the angular displacement of the arm and the response is optimized for high rotating velocity, high accuracy level, considerable range of concentrated masses and under undetermined initial conditions (angular velocity and acceleration) between two consecutive commands.

To the formation of the objective function of the parameter optimization problem, the mean absolute approximation error of the current desirable position (command), the overshooting between two consecutive commands and the amplitude of the oscillatory (high frequency) part of the response in total are participating. The control variables of the optimization problem are the multipliers of the non linear loop and the three coefficients of a linear second order filter to which is inserted the first time derivative of the feedback. The movement scenario includes four different control commands which are activated at consecutive times.

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Towards Intelligent Machines: Theory, Technologies and Experiments

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Keywords: Inteligent Machines, Powered Wheelchairs, Learning, Reactive Control

ABSTRACT

Great efforts are being devoted in developing intelligent machines in Universities and Industry research laboratories all over the world. Intelligent machines will have strong social and economical impacts namely in manufacturing, defense, food industry, oceans and space exploration, medicine, rehabilitation, highway and urban transportation. Intelligent machines that can sense their environment, reason, self-acquire skills by learning, and act on it, require the integration of real-time software and modeling with sensors and precision mechanisms. In this paper, firstly theory and technologies for intelligent systems are examined concerning, namely, sensing, perception, learning and architectures. Secondly, experiments performed in these areas, in the framework of two projects under development in the Institute for Systems and Robotics are examined.
The first one, the RobChair project [1], was conceived with the aim to assist disabled people in the difficult task of operating a powered wheelchair. At its current stage, the wheelchair project supports semi-autonomous navigation with the following features: uses fuzzy-logic based reactive navigation, allows remote operation by Internet observers through a 3-D Graphical User Interface (GUI) and can be activated by voice.
The second project is concerned with self-learning of robot control skills [2] and with mobile robot path-learning for the robot moving in unknown environments [3].

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An Attribute Grammar Driven High-Level Synthesis Paradigm for Control Applications

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EXTENDED SUMMARY

Attribute grammars (AGs) were devised by Knuth [7] as a tool for the formal specification of programming languages. In the general case, an AG can be seen as a mapping from the language described by a *context free grammar* (CFG) into a user defined domain. Since their introduction, AGs have been a subject of intensive research [10], both from a conceptual and from a practical point of view producing a large number of automated AG based systems. These systems, usually called *compiler-compilers*, generate different kinds of language processors from their high-level specifications. The development of such systems is the main advantage of AGs over other formal specification methods, since they can also be used as an executable method. This advantage has made AGs one of the most widely applied semantic formalisms.

In the field of electronic design automation, high-level automated synthesis of special purpose architectures [6], [8], [11], [14] presents many similarities with the work undertaken by a traditional compiler. It is defined as the transformation of behavioral circuit descriptions into *register-transfer level* (RTL) structural descriptions that implement the given behavior while satisfying user defined constraints, and can be seen as either a compilation process, or a dataflow computation over a loosely defined (constrained) hardware architecture. The result of this transformation is the exact definition of the optimal (or suboptimal) architecture for each given behavior, with respect to timing constraints, area constraints and more recently power consumption constraints and test resource constraints.

Recently, a unifying formal framework for high-level synthesis ([3], [5]) has been proposed based on AGs. Its main functionality is to transform algorithms into architectures. The implementation of a hardware compiler, producing VHDL [1], [9] descriptions of the synthesized circuits and based on the ideas of [3], has been presented in [4]. Earlier, other formalisms for the automated synthesis of special purpose architectures had been investigated, like FP [12] and PROLOG [13].

This paper faces the problem of high-level synthesis of control applications in the same AG-driven environment, tuned to handle such cases efficiently. As an example, a Kalman filter (one of the benchmark circuits in [2]) is automatically produced. The basic requirements at the algorithmic level are discussed (like matrix multiplication, parallel or serial input feeding, e.t.c.) and special solutions are given in an AG formalism. The proposed approach raises the level of abstraction for high-level hardware synthesis of control applications. The implementation of a hardware compiler can focus on how the required algorithmic transformations operate and not on the particular programming language constructs and techniques that are needed for their realization. AGs are used as a meta-tool, supporting transformations driven by attribute dependencies.

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An Intelligent Agent Framework in VRML Worlds

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Intelligent Agents' technology [1,2,3] has presented many applications so far, starting from smart e-mail clients to software for robotics applications. There have also been remarkable attempts from either software companies or university research teams to put an intelligent front-end to Internet applications, such as intelligent interactive systems which are usually implemented with Java applets.

In this paper we present the architecture of an Intelligent Agent which consists of a logical core as well as a virtual representative. The Logical structure provides the agent with reasoning capabilities [3] as well as domain knowledge [2]. The virtual world is represented as a 'mental' structure in the agent's knowledge base. The agent is not only perceiving, deciding and acting, but his actions (movement, object manipulation, etc.) are visualized as the actions of a virtual 'avatar' in a VRML world [4].

The system uses a 2-tier Client/Server architecture, with Java/VRML on the client side and C++/Prolog on the server side. The C++ program is used as a gateway to a Prolog meta-interpreter which reasons and determines the actions of the agent. Subsequently these actions are sent as commands to a Java applet, using network sockets. Finally, the Java applet hosts a VRML world where the Agent exists as an avatar.

Finally, a toy example is presented where an intelligent agent finds his way out of a maze after having to discover some key-information in the maze, and its virtual representative (avatar) is directed through the VRML world following the agent' s orders.

The applications of such a structure are numerous, including educational software, intelligent VRML micro-worlds, role playing games, interactive movies, etc. We are currently working towards extending the reasoning abilities of the agent, introducing multiagent worlds with increased complexity.

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A Multi-Agent Model for Content-Based Electronic Document Filtering

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Abstract

The huge volume of heterogeneous and distributed information that is nowadays available in electronic documents forces a lot of people to consume a significant percentage of their time looking for documents that contain information useful to them. The filtering of electronic documents seems to be hard to automate, partly because of document heterogeneity, but mainly because it is difficult to train computers to have an understanding of the contents of these documents and make decisions based on user-subjective criteria.

In this paper, we suggest a model for the automation of content-based electronic document filtering, with emphasis on the homogeneous treatment of electronic documents, personalization and dynamic adaptation to the user needs, and automatic training. The model is based on multi-agent technology and utilizes a knowledge base organized as a set of logical rules. Implementations of the model that make use of client-server architecture should be able to efficiently access documents distributed over an intranet or the Internet.

The primary components of the model are four cooperating intelligent agents and a user-specific knowledge base. The tasks performed by the agents are: (i) extraction of meta-data from the documents, in the form of headers; (ii) filtering of documents based on their headers; (iii) presentation of the results and user control; and (iv) information seeking. A rule-based model has been adopted for the knowledge base, in which the user-subjective criteria for the filtering are stored.

A partial implementation of the suggested model, called ALEC, has been developed for personal computers. ALEC has been used experimentally in the environment of a journalist's office. Although the implementation is still premature, and there are no substantial and trustworthy results yet, the first experiences from its application are very promising.

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Introducing Automated Gesture Recognition: The Gesture Segmentation Problem

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Recent interest in Gesture Recognition has been motivated by its obvious potential for applications in natural user interface design. It is widely believed that as the computing, communication and display technologies progress even further, the existing Human-Computer Interface (HCI) technologies may become a bottleneck in the effective use of the available information flow.
Nevertheless, a major impulse to the development of gestural interfaces has been motivated by the need for robotic manipulations imposed by gestures of a human operator. To perform manipulation of objects through HCI a combination of coarse tracking and communicative gestures is currently being used. For example to direct a computer or a robot to rotate an object a user of such an interface may issue a two-step command: <select_object> + <rotate_object>.
Our objective is to build an integrated and robust Gesture Recognition system composed of subsystems performing:

- Gesture Segmentation
- Gesture Analysis
- Gesture Recognition

At this paper we have considered only the Gesture Segmentation subsystem.
We have consider two of the most promising techniques proposed for the solution of the general problem of both segmenting a noisy intensity image and tracking 3D deformable objects as they move and deform in the plane. These are (i) the Active Contours and (ii) the Deformable Templates techniques.
Although both techniques have very sound analytical foundations, there is still a lot of work to be done in order to robustly treat real applications, since every application introduces special difficulties. For example, Gesture Recognition involves very complex geometries especially at those points close to the finger base where two fingers meet. The Active Contour methodology if not endowed with a special design cannot follow such a sharp gradient change. In more technical terms it is required to incorporate special divergence terms in the image diffusion equation.
In recent publications we have seen the segmentation of vehicles, handwritten digits and characters, industrial parts, and many other simple rigid objects using deformable templates. The application of deformable templates in Gesture Recognition imposes a lot of difficulties, since the movement of fingers and the twist of arm make the construction of a scale and rotation invariant prototype a very challenging task.
In this paper, we propose a scheme incorporating the above methodologies in order to relax their inevitable drawbacks and enhance their merits.
First, we have evaluated the performance of each the two aforementioned segmentation schemes for the Gesture Segmentation problem. The criteria considered were computation time and segmentation accuracy. Active Contours have the advantage of high segmentation accuracy, but the initial position of the 'snake' should be close enough to the object of interest in order to guarantee convergence. On the other hand, Deformable Templates can work no matter how far is the initial position from the object, but the segmentation is less accurate.
Our fundamental idea is to achieve enhanced accuracy and stability even in the difficult segmentation problem introduced by Gesture Segmentation in natural scenes.

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A Scada System with Embedded KBS for Diagnostics

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ABSTRACT

The development of an open Knowledge Based System in the form of tasks and subtasks, provides an elegant way of rapid program development. This approach leads to the design of a digital control system with generalized functions for process control, configurable to meet specific control requirements. Intelligence is shared among low level control loops in the controller and high level decisions made at the central process computer. The system can operate in "central", "autonomous" or "hybrid" mode. New control scenarios may be implemented by adding new tasks. This approach provides unlimited task sequences, based on a well designed set of abstract equipment drivers. It effectively provides a vehicle for immediate exploitation of new control philosophies based on tuning results or operator's experience.

Our system consists of two subsystems: the "virtual control subsystem" and the "fuzzy inference subsystem". The VCS is a conventional plant control system based on enhanced with Virtual Variables. These VVs can implement system or function models out of a big collection of functional templates and can generate desired trajectories, of the "expert type/user defined" or "model referenced adaptive setpoints". One type of a VV is a fully bundled non-linear PID loop, which can be assigned to track these trajectories. These virtual control loops can be cascaded or nested to develop multiple loop systems. An embedded optimizing tool can be activated to optimize the PID, or another's VV parameters, conducting on-line experiments, based on a given performance function and a modified descent method searching for the global minimum. This subsystem is a shallow knowledge system, which selects and executes plant operations according to some events prescheduled by the operator. Some of the VVs may implement a plant "monitor" to detect unforeseen abnormal situations, which shall be processed by the FIS.

The FIS is a native fuzzy inference system, which can interact and cooperate with the VCS. One class of rules that can be implemented, are diagnostic rules. Given an abnormal situation, alarmed by the "plant monitor", the FIS can refer to linked "devices' models" and "operation's model" to apply a "resolution plan" to deal with the situation (i.e. disable a control loop, change setpoints of a process, change the limits of an actuator, replace an actuator and the control parameters, etc). An example is presented of the actions taken by the FIS on a malfunction of a liquid mixing process, which involves a number of actuators experiencing big load changes, as used in a greenhouse to prepare the nutrients solution for plants.

Keywords: fault detection, intelligence, process control, knowledge based system

Parametric Representation of Basic Human Locomotion

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ABSTRACT

In this paper we describe elementary human motion, using a simplified, but adequate model of the human body. We propose a holistic set of parameters which can reproduce actions, such as walking and running, for the purposes of animation, based on a relatively simple skeleton model which consists of a hierarchical structure of nineteen rotational joints. Similar models have been used in previous work on human body animation [1,2] and have been proved effective for describing holistic characteristics of human body locomotion, since they are based on biomechanical data [3]. Human walking and running is a periodic, cyclical motion. Previous work in the fields of kinesiology [4] and animation [5] indicates that we can detect a number of distinguishable phases during a human gait or run cycle. In our work we divide each cycle into two halves, one for the motion of each leg. During the first half, the skeleton model goes through the extended, recoil and passing positions and also a fourth one, which is the anticipation phase during the gait cycle and the airborne phase during the run cycle; the second half of the cycle is a mirror of the first. Each phase can be identified by the values of a set of parameters, which are in essence angles between the jointed segments of the skeleton model. Actually, in each of these phases some parameters obtain their maximum or minimum values. Given the posture of the model in each of the phases described above, which can be defined by that set of parameters, we can produce realistic movement for the model. By altering the values of the parameters for each phase, within the joint rotation limits set by the model, we can create a library of motion templates, which can be used either in computer performance animation or in robotics systems, as well as in motion detection and classification.

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Harmonic Analysis of Linear Sampled-Data Systems

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ABSTRACT. An important feature of linear time-invariant systems is that they can be represented as a multiplication operator in the frequency domain, i.e., a frequency transfer function. Unfortunately, this framework is no longer applicable to sampled-data systems, as these systems become periodically time-varying when viewed in the continuous-time domain. For example the continuous-time steady state response of sampled-data systems contains a large number of frequency components. Two approaches to deal with the concept of frequency gain for these systems have been recently introduced [1], [2]. In this paper, we further investigate the concept of frequency gain of sampled-data systems using an alternative point of view based on a symmetry argument which we exploit via a group theoretic approach. More precisely, it is a generalized Fourier analysis which consists of expansion of sampled-data systems with respect to their "harmonics". Here the notion of "harmonics" appears in presence of some action associated with a specific group of transformations. Under this action, the functional space $L_2(R)$ decomposes into a *direct integral* of simplest parts (the "harmonics"), i.e., elementary subspaces which are invariant. It is shown that this direct integral decomposition induces a corresponding decomposition of a bounded sampled-data operator on $L_2(R)$ and the restriction of this operator to the "harmonics" defines an operator-valued function of the frequency variable which has the nice properties of the frequency gain of linear time-invariant systems.

Keywords : Frequency response, harmonic analysis, sampled-data systems, periodic systems, groups, linear representation theory

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WEAKLY POSITIVE CONTINUOUS-TIME LINEAR SYSTEMS

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Let $R^{n\times m}$ be the set of $n\times m$ real matrices and $R^n := R^{n\times 1}$. Consider the singular continuous-time linear system

(1a) $$E\dot{x} = Ax + Bu,\ x(0) = x_o$$

(1b) $$y = Cx + Du$$

where $x\in R^n$ is the semistate vector, $u\in R^m$ is the input vector, $y\in R^p$ is the output vector and $E\in R^{n\times n}, A\in R^{n\times n}, B\in R^{n\times m}, C\in R^{p\times n}, D\in R^{p\times m}$ with E possibly singular.
The system (1) is called standard if and only if $E = I_n$. The system (1) is called regular if and only if

(2) $\det[Es - A]\neq 0$ for some $s\in \mathbf{C}$ (the field of complex numbers)

Let R_+^n be the set of n-dimensional real vectors with nonnegative components.

Definition 1. The system (1) is called positive if and only if for all $x_o\in R_+^n$ and $u(t) = u\in R_+^m$, $t\geq 0$ we have $x(t) = x\in R_+^n$, $t\geq 0$ and $y(t) = y\in R_+^p$, $t\geq 0$.

Definition 2. A matrix $A\in R^{n\times n}$ is called the Metzler matrix if all its off-diagonal entries are nonnegative.
It is easy to show that $e^{At}\in R_+^{n\times n}$ if and only if A is a Metzler matrix. The standard system (1) (with $E = I_n$) is positive if and only if A is a Metzler matrix and $B\in R_+^{n\times m}, C\in R_+^{p\times n}, D\in R_+^{p\times m}$.
Definition 3. The system (1) is called weakly positive if and only if A is a Metzler matrix and $E\in R_+^{n\times n}$, $B\in R_+^{n\times m}, C\in R_+^{p\times n}, D\in R_+^{p\times m}$
A standard system which is equivalent (has the same solution) to the singular (regular) continuous-time linear system will be derived. Necessary and sufficient conditions will be established under which a weakly positive singular continuous-time system can be transformed by the strict equivalence to a positive system. Some properties of weakly positive continuous-time linear systems will be characterised

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Some Results On Nonuniversal Polynomial Inputs

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Abstract. The concept of the observer plays the very important role in state estimation problems. Nowadays there exist a lot of papers concerning universal observers, see e.g. [1] and the bibliography in it. The most part of these papers is related to bilinear systems. Construction of universal observers for polynomial control systems is still nonexamined because of complicated geometry of the set of universal polynomial inputs in the space of all polynomial inputs, [2, 4]. The goal of this paper is to demonstrate that the set of all nonuniversal polynomial inputs in the polynomial situation has one fundamental property given below. We consider the polynomial control system $\sum$:

$$\dot{x} = f(x,u); y = h(x); x \in \mathbf{R}^n; \mathbf{u} \in \mathbf{R}^1; \mathbf{y} \in \mathbf{R}^p$$

Theorem 1 *Let W be a set of nonuniversal polynomial inputs $u : [0,T] \to \mathbf{R}^1$, $T > 0$. for the system $\sum$. Then the set $\{\deg u | u \in W\}$ has the uniform upper bound.*

The proof is realized in a few steps. Firstly, we prove that it is sufficient to establish our assertion for linear-in-control homogeneous with respect to x polynomial vector fields. Then we obtain an algebraic differential equation $\Psi(u, \dot{u}, ..., u^{(k)}) = 0$ such that any nonuniversal polynomial input is a solution of it; here k is the degree of universal polynomial inputs, [2, 3]. Finally, we obtain the necessary upper bound given in terms of Ψ. We discuss applications of this theorem to some special cases of $\sum$.

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ANALYSIS OF PROPERTIES OF MULTITIME SCALE SYSTEMS IN 2D APPROACH

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Abstract : Many realistic large-scale systems (e.g. power systems, economis systems etc.) consist of many elements of very wide range of time constants (different speeds of dynamics). Such a situation, when a system behaviour/dynamics depends on both slow and fast speeds can be used to divide such a system into two (or in general more than two) sub-systems of less dimensions and hence easier for analysing. However such approach is asymptotic, that is the obtained results are only an approximation of the real results. The approximation is better if the two (or more) separate parts interact together enough weakly.

In the paper the so-called multitime scale systems (MSS) are described in terms of discrete linear repetitive processes which belong to the family of well known 2D systems. Some improvements to the previously developed model [1] are introduced, however the main results (e.g. similarity to the linear repetitive processes) is not affected. Some new results in analysing of the properties of the model are reported. The main focus is put on controllability, stability and stabilizability of the model.

To improve possibility of making some practical simulations of the model a new MATLAB-based tool was developed which gives an intuitive interface and simplify simulation tasks which are being made. This tool is a part of the general 2D systems toolbox which is extensively developed. During the presentation of the paper a short demonstration of the tool will be provided.

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Two New Methods for Checking the Stability of 2-D Systems

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Abstract. In this paper, two new methods for checking the stability of 2-D systems are presented. The first method is formulated by way of a theorem: Theorem 1: $B(z_1,z_2)\neq 0$, for $|z_1|\leq 1$, $|z_2|=1$, (where $B(z_1,z_2)=\sum_{i_1=0}^{N_1}\sum_{i_2=0}^{N_2} b_{i_1,i_2} z_1^{i_1} z_2^{i_2} = \sum_{i=0}^{N_1} b_i(z_2) z_1^i$) if and only if the matrix $C(z_2)=a_0^*(z_2)A^{N_1}+a_1^*(z_2)A^{N_1-1}+\ldots+a_{N_1-1}^*(z_2)A+I_{N_1}$ is positive definite for all z_2, with $|z_2|=1$ (the asterisk indicates complex conjugate), where

$$A=\begin{bmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ & & \vdots & & \\ 0 & 0 & 0 & \cdots & 1 \\ -a_0(z_2) & -a_1(z_2) & -a_2(z_2) & \cdots & -a_{N_1-1}(z_2) \end{bmatrix}$$

and $a_i(z_2)=\dfrac{b_{1,i}(z_2)}{b_{1,N_1}(z_2)}$ or equivalently $a_i(z_2)=\dfrac{b_{N_1-i}(z_2)}{b_0(z_2)}$ $\quad i=0,\ldots,N_1-1.$

An improvement is provided by the following theorem: Theorem 2: $B(z_1,z_2)\neq 0$, for $|z_1|\leq 1$, $|z_2|=1$ if and only if the matrix $C(z_2)=\bar{a}_0(z_2)A^{n_1}+\bar{a}_1(z_2)A^{n_1-1}+\ldots+\bar{a}_{n_1-1}(z_2)A+I_{n_1}$

(i) is positive definite for a z_2, with $|z_2|=1$, and

(ii) $\det\{C(z_2)\}>0$ for all z_2 with $|z_2|=1$.

The second method is the method of the Partial Energies. It is known that for an 1-D polynomial, if it is stable, its partial energies are greater than the corresponding partial energies of its reciprocal polynomial.

For 2-D polynomials we can exploit this property as follows: A 2-D polynomial is considered as 1-D in one complex variable with its coefficients depending on the other complex variable. Based on Huang's theorem and on the above property of Partial Energies, we can derive an elegant criterion for 2-D (Schur) stability which provide us with necessary conditions for 2-D (Schur) stability (equivalently sufficient conditions for instability). The method provides better necessary conditions than those of the relevant technical literature. This means that, in some cases, where other criteria from the literature fail, the present proposed method "works"!

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A Robust Frequency Domain Identification Method Revisited.
Application in Steel Casting.

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The most critical task when designing a *model based predictive controller* is identifying a reasonably good process model. This is a non-trivial task for the kind of *real-life application* considered here: the mould level control of a continuous casting line in a steel factory. Due to the extremely high stochastic disturbance level, well-known time-domain identification methods (such as least-squares or prediction-error identification) were not successful. A simple though robust method, based on sinusoidal test inputs and frequency domain identification, gave satisfactory results.

In recent years, identification techniques based on frequency domain methods (such as orthonormal basis functions or time-frequency/wavelet analysis) are rapidly developing and widely used in many areas such as filtering, prediction, time-varying process control, on-line detection. The method presented in this paper is based on the use of orthonormal basis functions to obtain the process frequency response (Bode plot) as a first step. A parametric transfer function model is then obtained as a second step. The use of orthogonal detection resulted in a method that turned out to be very robust, even in the case of a bad signal/noise ratio. It led to a simple and stable algorithm that could be used for *real-time* identification in *closed-loop*.

The identification method can be implemented by adding a low-frequency sine test-input with varying frequency to the setpoint. It does not disturb the normal process operation. Moreover it is quite attractive for practical applications thanks to its simplicity and robustness.

The method is applied to real-life data obtained in a steel factory. The resulting models have been the basis for a predictive controller for the mould level regulation of a continuous casting line. Continuous bloom casting is the process of moulding molten steel into solid slabs. The mould level process, which is a critical part in the casting line, is a very tough system to model and control because of the presence of pure integrators in the process, time-varying characteristics and a very high level of stochastic disturbances.

The experiments with our method on the real casting line indicated that this is a realistic approach for identification in such an adverse environment.

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Identification of NonMinimum Phase Finite Impulse Response (NMP FIR) systems Using The Fourth Order Cumulants

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ABSTRACT

In recent years, the estimation of the parameters of a NMP FIR system, based on higher statistics of the noisy observations of its output, has attracted considerable attention. In fact, several methods using cumulant statistics for the identification of NMP FIR systems have been proposed in the literature. These methods can be classified in to three categories of solutions: recursive form solutions, linear algebra solutions and optimization solutions. Only the linear algebra solutions are considered in this paper. They consist of constructing overdetermined systems of equations relating correlation with either third or fourth order cumulants to the impulse response coefficients and resolving these systems by using the least squares approaches. The performance of these methods degrades when the data are contaminated by white or colored Gaussian noise because the correlation is not blind to it. Moreover, most of these methods propose a vector of unknown parameters whose elements are related to each other. In fact, the obtained systems are nonlinear, hence requiring nonlinear algorithms to be solved. To overcome these problems, we propose in this paper a linear algebra method that can be used to identify the parameters of NMP FIR systems using higher-order statistics. The developed method presents several interesting differences with respect to existing methods. The new characteristics can be summarized as follows:

- The parameters are obtained from fourth order cumulants leading to consistent estimates in the presence of white or colored Gaussian noise of unknown variance.

- The unknown vector parameters defined by $\theta = \left[h^3(1)...h^3(q)\ h^2(q)\right]^T$ is truly linear in (q+1) coefficients, hence the least squares approaches give an optimum solution.

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A Matlab-Based User Friendly Graphical Environment for Control System Analysis and Design

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Abstract

This paper presents a user-friendly and comprehensive **CO**ntrol System **A**nalysis and **D**esign (**COSAD**) environment built on the platform of Matlab 4.2.c., which is easy to use and does not require the knowledge of a computer language. It is a typical graphical environment (the system editing, analysis and design functions are carried out via pull-down menu, push buttons, check and dialogue boxes etc.) using the available interface features of MATLAB. There are many benefits to be gained by having available software for System Analysis and Control System Design, which does not require the user to be familiar with Matlab (or Matlab Toolboxes as Simulink) or to write any computer code. The objective is that users of COSAD system can design satisfactory controllers, even if they do not have much experience in control system design, using a high-level graphical environment in fields such as **Education**, **Research**, **Engineering Applications**.

The software has been developed so that the user with a knowledge of basic control theory and a familiarity with the windows environment to be able to do a large repertory of classical control analysis and design studies on a basic SISO control loop including a plant, controller and feedback element without any knowledge of MATLAB. The main advantages, apart from the excellent user interface for inputting data, are the availability of multiple response graphs in different windows, the evaluation of control performance parameters, the easy availability of many options for both inputting parameters and displaying results (animation of results), and finally the embedded control algorithms for the calculation of different control laws. The paper includes several examples to show the type of results that are obtained by COSAD.

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DEVELOPMENT OF A MATLAB TOOLBOX FOR A CLASS OF 2D LINEAR SYSTEMS

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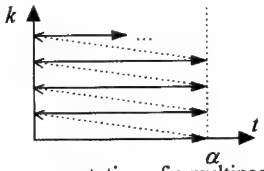
Abstract : The essential unique characteristic of a repetitive, or multipass, process is a series of passes through a set of dynamics defined over a fixed finite duration termed the pass length. The key feature of interest is the fact that the information propagation in one of the two separate directions evolves continuously over a finite fixed interval while in the second direction is discrete. It is necessary to use two co-ordinates to specify the pass number $(k >= 0)$, and the position t along a given pass which is always finite and fixed and we denote it here by α.



General dynamic representation of a multipass process

The dynamic of such a process on *k-th* pass evolves along t and is known as the pass profile which ends by definition at α. The next pass profile is produced in the same way on *(k+1)-th* pass which depends on the previous one. Repetitive processes also exist where more than one previous pass profile contributes to the current one.

This paper describes the MATLAB based Toolbox for analysis of Linear Repetitive Processes (LRP) and some on-going work on theirs synthesis. The basic LRP equations are discrete in one direction (pass numbers) and continuous in the second (position along a given pass). For simulation purposes various 2D discretization methods are used to obtain the discrete-discrete model. Moreover various initial conditions were implemented in the Toolbox from the simplest one to those which are a function of the previous pass profile.

During pre-synthesis work some methods of checking controllability of LRP were proposed and implemented. These methods use very promising approach to the analysis of such processes e.g. 1D representation of LRP. The unique feature of such 1D equivalence is that the matrices used are of constant dimensions and this fact gives very prosperous tool for future analysis tasks.

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BIBO STABILITY OF SPECIAL NONLINEAR DISCRETE SYSTEMS

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1 Abstract

In this paper we shall be dealing with the BIBO stability problem of systems of the form:

$$y(t)+\sum a_i y(t-i)+\sum a_{ij} y(t-i)y(t-j)+\cdots+\sum a_{i_1,\ldots,i_n} y(t-i_1)\cdots y(t-i_n) =$$
$$= u(t)+\sum b_i u(t-i)+\sum b_{ij} u(t-i)u(t-j)+\cdots+\sum b_{i_1,\ldots,i_n} u(t-i_1)\cdots u(t-i_n)+$$
$$+\sum c_{i_1 i_2 \ldots i_n j_1 j_2 \ldots j_m} y(t-i_1)y(t-i_2)\cdots y(t-i_n)u(t-j_1)\cdots u(t-j_m)$$

The cornerstone of our method is the notion of the star-factorization. This is a factorization coherent with the star-product, an operation related with the algebraic structure of these systems. The star-product is a mathematical concept that facilitated the description of discrete input/output systems and helped us to derive the solution to some certain problems. In the current paper we extend the whole methodology so that to derive a star-factorization algorithm, proper for systems containing cross-products among inputs and outputs. Then, under some certain conditions we could write these systems as a star-product among a non-linear polynomial and a linear one. Some assumptions, involving the coefficients of the linear polynomials, guarantee the BIBO stability of the whole system. Therefore the whole approach constitutes a pragmatic computational method, very useful for direct applications, and totally different from any previous one.

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FAULT DETECTION IN FLIGHT CONTROL SYSTEMS VIA INNOVATION SEQUENCE OF KALMAN FILTER

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ABSTRACT: In this paper , a real-time approach to detect the faults affecting the covariance matrix of the Kalman filter innovation sequence is presented. The ratio of two quadratic forms of which matrices are theoretical and selected covariance matrices, as monitoring statistics, is used. The arguments of the optimal quadratic form that maximize the above statistics are determined to detect faults in the sensors rapidly. The approach does not require a priori information about the faults and statistical characteristics of the system. The longitudinal dynamics of an aircraft control system, as an example, is considered, and detection of various sensor faults affecting the mean and covariance matrix is examined.

Faults in dynamical systems can be detected with the aid of an innovation sequence. If the system operates normally, the normalized innovation sequence in a correlated Kalman filter is a Gaussian white noise with a zero mean and with a unit covariance matrix. Faults that change the system dynamics by causing surges of drifts of the state vector components, abnormal measurements, sudden shifts in the measurement channel, and other difficulties such a decrease of instrument accuracy, an increase of background noise, etc., affect the characteristics of the normalized innovation sequence by changing its white noise nature, displacing its zero mean, and varying unit covariance matrix. Thus, the problem is how to detect as quickly as possible any change of these parameters from their nominal value. The paper is aimed to propose a solution for the above problem.

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Control System Design using Global Optimization Techniques

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Abstract

It has been shown [1, 2] that many problems in control theory for linear time-invariant systems (e.g., parametric stability margin computations, multiobjective robust synthesis, etc.), can be formulated as the constrained minimization of a scalar function, i.e.:

$$\min_{\mathbf{q}\in\mathbf{\Gamma}} \quad \mathcal{J}(\omega,\mathbf{q},\mathbf{p})$$
$$\text{subject to: } \begin{cases} \mathcal{G}_1(\omega,\mathbf{q},\mathbf{p})>0 \\ \vdots \\ \mathcal{G}_N(\omega,\mathbf{q},\mathbf{p})>0 \end{cases},$$

where the vector $\mathbf{p}\in\mathbf{\Pi}$ represents plant uncertainties, the vector $\mathbf{q}\in\mathbf{\Gamma}$ represents controller parameters, $\mathbf{\Pi}$ and $\mathbf{\Gamma}$ are hyperrectangles, and ω is the frequency, $\omega\in[\omega_{\min},\omega_{\max}]$.

The *multivariate* inequalities in the above problems are derived from closed loop stability requirements (Routh-Hurwitz criterion) and from loop-shaping inequalities of the type

$$f_{\min}(\omega) < |H(j\omega,\mathbf{q},\mathbf{p})| < f_{\max}(\omega),$$

where the transfer function $H(s,\mathbf{q},\mathbf{p})$ can be either the *Sensitivity function* $S(s)$, or the *Complementary sensitivity function* $T(s)$, or any another relevant transfer function. It is important to recognize that only the *global* minimum of the above problem is of interest.

In this paper we present the application of a novel *global* optimization technique to the solution of such problem. This technique is based upon the algorithm proposed in [3] for unconstrained, unidimensional global optimization. The extension to multidimensional problems is accomplished using space-filling curves: the constraints are taken into account by means of suitable penalty functions. Furthermore, a relevant feature of the proposed technique is the possibility to implement it on parallel computers to speed-up computation.

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Design of Adaptive LQ Optimal Trackers Based on Multirate Sampling of the Plant Output

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ABSTRACT: In this paper, the use of a specific class of sampled-data controllers, namely the multirate-output controllers (MROCs), in order to achieve adaptive linear quadratic (LQ) optimal tracking of linear systems with unknown parameters, is investigated. In particular, the certainty equivalence principle is used to combine the identification method with a MROC based LQ control structure, which could be used to meet the LQ optimal tracking control objective in the case of plants with known parameters. The multirate-output LQ optimal trackers proposed in the paper, contain a sampling mechanism in which the system output is detected many times over one sampling period, and its multirate sampled-data over a fundamental sampling interval are appropriately used for feedback. Such a control strategy provides, for the output of the sampled closed-loop system, the ability to track the output of a given reference model, subject to a quadratic cost criterion, without making assumptions on the plant other than controllability, observability and known order. A uniformly convergent and globally stable indirect adaptive control scheme is derived, which, on the basis of a modified recursive least square algorithm, estimates the unknown plant parameters (and consequently the controller parameters) on-line, from sequential data of the inputs and the outputs of the plant, which are recursively updated within the time limit imposed by a fundamental sampling period T_0. Using the proposed algorithm, the adaptive LQ optimal tracking problem considered, is reduced to the determination of a fictitious static state feedback controller, due to the merits of the proposed multirate-output controllers. Known techniques for indirect adaptive LQ optimal tracking usually resort to the computation of full order adaptive state observers, thus introducing high order exogenous dynamics in the control loop. The proposed control strategy avoids the need for state observers, since, exact reconstruction of the systems state is feasible here. Thus, the MROC based LQ trackers are optimal in the sense that no approximate estimation of the state vector through states observers is made here, as in known techniques. The exogenous dynamic introduced by our method is of low order. Moreover, persistency of excitation and, therefore, parameter convergence of the continuous-time and the sampled plant under control, is provided without making any assumption either on the existence of specific convex sets in which the estimated parameters belong or on the coprimeness of the polynomials describing the ARMA model, as compared to known indirect adaptive schemes for LQ optimal tracking.

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A New Global Optimization Algorithm Combining the Natural Evolution Model and the Deterministic Newton Methodology

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ABSTRACT

A new global optimization methodology is proposed, which is based on a combination of the model of natural evolution and the deterministic Newton methodology deriving only zeroth order information of the problem analysis (objective function values). At the first stages of the optimization process a series of points (groups of generations) is produced according to the evolution strategy. As soon as the amount of the available information (analyzed points) exceeds a pre-set value which depends on the amount of the control variables, a Newton type optimization process is introduced. During this process in each Newton iteration of the algorithm, a smoothed quadratic approximation of the objective function is formed, with a specified starting point, based on the available information 'values of the objective function'. In opposite of the classic quadratic approximation, the smoothed quadratic approximation can incorporate unlimited amount of available information and constitutes the member of the quadratic functions set for which the sum of the second power of the approximation errors is minimized with respect to a specific set of available points. Utilizing the information which was produced at the previous stages of the optimization process, higher level information is produced, if opposed to the one that can be supplied or is supplied due to computational capacity limitations, by the problem analysis.

The proposed algorithm takes advantage of the deterministic model of the smoothed quadratic approximation, incorporating an unlimited pre-selected amount of information. Additionally, it does not stick to the local formation of the objective function, at any stage of the optimization process. This way, a remarkable combination of the major advantages of the deterministic (fast and accurate location of the optimum) and the evolution methodologies (escape from a local optimum region) are provited. This algorithm is proved to be more efficient than the deterministic 'Newton type' and the 'Evolutionary' algorithms, especially when the problem to be solved appears all or most of the following peculiarities: Presence of many local minima or more than one global minima, abrupt variations of the objective function, discontinuities, non defined or discontinuous first and second order derivatives, high analysis computational cost and small up to medium number of control variables (up to some decades).

In order to test the effectiveness of the proposed algorithm a number of numerical experiments have been performed for test functions commonly used as benchmarks.

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Using Karhunen - Loeve Transform in Feature Extracting Phase

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Abstract: In recent year's research, it has been shown that the use of cepstrum coefficients alone in speaker-independent speech recognition is far from enough. In order to reduce the influence of different speakers to the recognition system, many methods have been put forward to strengthen parametric representation with dynamic information. The frequently used dynamic features include cepstrum differential coefficients and energy differential coefficients. The combination of static and dynamic information as features in speech recognition has achieved a good effect.

Each Dimension of feature vector is considered as independent of others in most of speech recognition system. The dynamic features extracting methods mentioned above are all processed by inter-frame. But, they do not consider the correlation among each dimension of frames' feature vectors and we think that they do not consider correlation among adjacent frames enough. In order to use the correlation mentioned above, we could incorporate them in the feature extracting phase or the acoustic-modeling phase. In this paper, we present a novel method to incorporate temporal correlation into a speech recognition system in feature extracting phase.

In feature extracting phase, we use the following method to obtain new feature vectors. At first, we calculate original features such as cepstrum coefficients derived by LPC analysis, etc. Then for each frame, the n frames ahead and the n frames after are all taken into account, we concatenate the feature vectors of them in time order that generate a new feature vector containing the information of 2n+1 adjacent frames. At last, these new feature vectors are dimension-reduced by Karhunen-Loeve transform. The data acquired now are used as this frame's feature vector in the following recognition.

It should be noticed that in the method mentioned above the first n frames and the last n frames of the original utterance have been less counted compared with other frames. So we present an extended method in which we insert the original feature vectors of frame 1, 2,..., n before our new feature vector sequence and append the original feature vectors of frame N-n+1,N-n+2,...,N after new feature vector sequence.

We implement our idea in a CDCPM-based speech recognition system. Firstly, we compare the first method with the second method in this paper. Secondly, we discuss on how many frames to be concatenated. Then, for KL transform matrix can be calculated by two modes which are all syllables share the same and each syllable has its own KL transform matrix, we discuss them in this paper too. At last, we present a new recognition system that contributes nearly 3 percent improvement to Top 1 recognition rate.

Keywords: Karhunen-Loeve transform, central distance continuous probability model (CDCPM), central distance normal distribution (CDN), continuous hidden Markov model (CHMM)

A COMPARATIVE STUDY OF WAVELET AND OTHER TRANSFORMATION METHODS USED FOR THE COMPRESSION OF DIGITAL IMAGES

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The purpose of this paper is to report the results of a comparison between classical and wavelet based transform techniques used for the lossy compression of digital images. The image compression process consists of the following steps: forward transformation, quantization and encoding. The reconstructed image is created using the inverse process namely decoding, dequantization, and inverse transformation. The transformations applied in this study are the classical transforms (discrete cosine transform, Walsh, and Hadamard) and the wavelet transforms (Haar and Daubechies D4). Discrete wavelets have been successfully applied in the compression of two dimensional images by using a multiresolution algorithm known as MRA. MRA decomposes the image into low and high frequency components (subbands), where the low frequency subband contains most of the energy of the image and is recursively decomposed into low and high frequency subbands until the m-levels is reached, where $N = 2^m$ for an NxN image. In this study, the scalar quantization/dequantization and the combination of run-length and variable-length coding methods have been used. The results have shown that the MRA method is the most efficient regarding higher compression ratio, better signal to noise ratio, and faster computational time. Although Haar wavelet transform gives out the highest compression ratio, the quality of the reconstructed image is the poorest. The performances of DCT, Walsh transform, and Hadamard transforms are good but require more computation time.

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Object Recognition using Shape Description and Wavelet Transform

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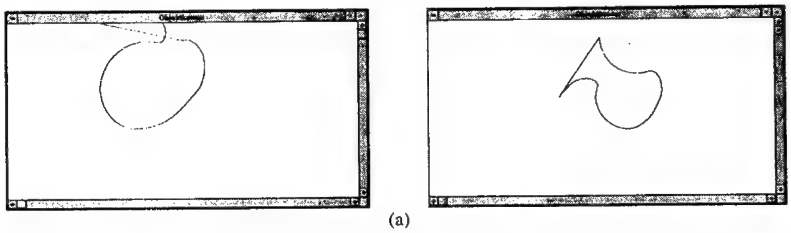
The Wavelet Transform (WT) is a power full algorithm for data compression and analysis in engineering applications. In the field of image processing, where the number of data is usually very high, the WT can be used to describe an image with small number of wavelet coefficients (WC). In some cases the number of WC can be reduced additionally using a threshold algorithm, in which all small coefficients can be rejected. In this case small details in the image, which are coded by the rejected coefficients will be neglected. This acts in many cases as a noise filtering.

The main purpose of this paper is to apply the WT and time frequence analysis for object recognition applications, similarly to the object recognition using Fourier transform. The contour of an object is transformed using WT and a given number of WC is applied to characterize the object shape. The object can be recognized by matching the WC of the given object with the WC of stored prototype using the minimum distance algorithm or another classification algorithm. To reduce the number of the WC a threshold method is used. The threshold algorithm can be used in every resolution stage of the multi resolution representation (MRR). Every stage of the MRR includes an approximated and detail signal. Fig. 1 shows the reconstruction of the triangle formed object (T-Object) and the square formed object (S-Object) on different resolution stages.

As it is shown in Fig. 1a only four WC is not enough for a good reconstruction of the contours in sense of mean square error criteria. For a good reconstruction it is necessary to have more coefficients as it is shown in Fig 1d (reconstruction with 32 WC).



(a)

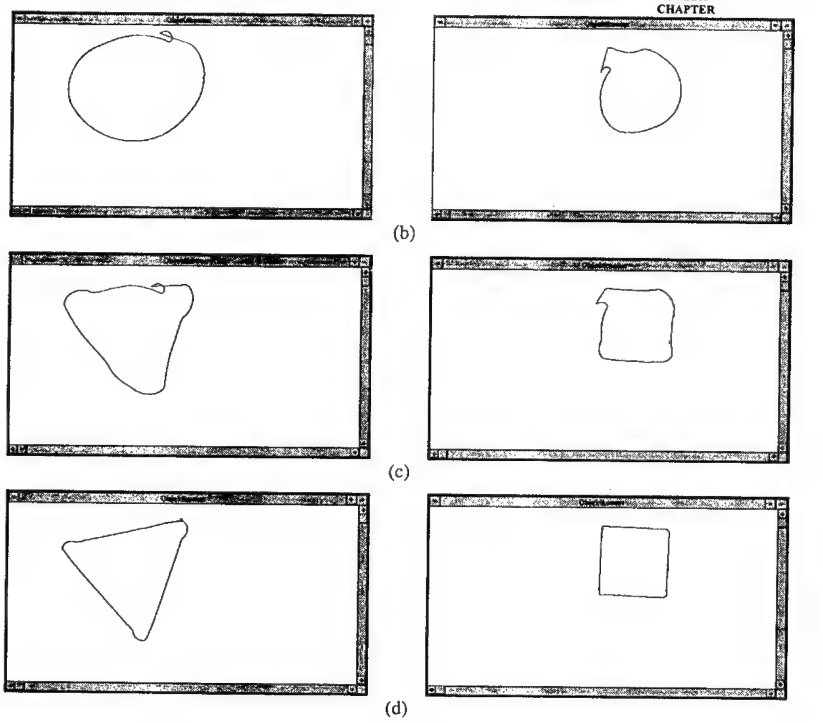


Fig. 1 Reconstruction of the contours T and S using several thresholds

For object recognition applications it is also necessary to use certain number of coefficients, which represent the object shapes. For study of the ability of the object recognition using WC we have investigated the T-object and the S-object shown in Fig. 1. One image was taken from the S-object and two images from the T-object in different positions and orientations. The contours of the objects (T1, T2, S) has been extracted using the object oriented contour extraction method and a polar vector description of the contours was applied to represent the shapes. The WT was done to get a number of coefficients to describe the extracted contours. The WC of T1 and S were stored in the memory to describe the known prototypes, and the WC of T2 were taken to describe the unknown object. The MRR was done till the last stage. To represent the objects we used 64 coefficients (4 from the approximated signal and 60 from the detail signal). We have used several thresholds M= 0.0, 0.1, 0.2, 0.5, 0.8 and Mmax) to reduce the number of coefficients of the detail signal which are not equal to zero.

Video Object Segmentation Using the EM Algorithm

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Abstract

Video object segmentation is an important task towards the framework of the MPEG-4 and MPEG-7 standardization phase. Especially, the MPEG group has adopted the concept of Video Objects (VOs) and Video Object Planes (VOPs) for improving the coding efficiency and providing multimedia functionalities to the future encoders [1]. VOs correspond to meaningful entities of arbitrary shape in a digital video stream, such as a human, a chair and so on, while VOPs are the projection of VOs into a plane. Such an extraction plays an important role in many other image analysis problems: content based image retrieval, reconstruction of a 3D human model from several 2D images, human face detection and recognition, video surveillance of specific areas, identification of objects by industrial robots and so on.

However, although humans effortlessly "perform" object segmentation, it remains one of the most difficult problems for computer systems, apart perhaps from the case of video games or graphics applications, where object segmentation is a-priori available. Current approaches to unsupervised image segmentation are based either on spatial or motion homogeneity criteria or a combination between them. Unfortunately, none of these techniques can provide satisfactory results towards the goal of video object segmentation since a video object generally contains regions of different colors and motions [2].

In this paper, we perform unsupervised video object segmentation based on an iterative maximum-likelihood (ML) scheme. In particular, the proposed method is applied for extracting of humans (head and body) from complex background, mainly in videophone applications. We consider that the probability density function (pdf) of the image to be segmented can be represented as a mixture of pdfs of individual objects (in our case human and background). Two approaches are examined. The first assumes that the image pixels and the classes, to which they belong, are independent. The second considers that image pixels and their respective classes, can be modeled as Markov Random Fields (MRFs) following Gibbs distribution. In this case improvement of object segmentation can be accomplished since this model better approximates the local correlation of color information which encountered in an image. Then, Expectation-Minimization (EM) algorithm [3] is applied to carry out the estimation of model parameters. However in the second case, it is more difficult to obtain simple expressions for the marginal expectation involved in the EM algorithm. Reduction of complexity can be achieved if approximation techniques are used for the marginal expectation, such as pseudo-likelihood approximation, which it seems to work well in practical applications.

The initial conditions of the EM algorithm are provided through an estimation module, which approximately indicates the human object location. In particular, the face is modeled as a unimodal Gaussian density where its mean value and variance are both estimated using a known training set. Then, based on previous probabilities, the face region is detected by taking into account all sub-images (blocks) whose the probability exceeds a certain threshold and then the face area and center are calculated. For the human body, a simplified model is considered as a product of two independent one-dimensional Gaussian pdfs.

The performance of the proposed scheme is evaluated using the MPEG-4 test video sequences. The main goal of the experiments is the human extraction (segmentation) from, even a complex, background.

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Transformations between Pictures and 3D Pattern

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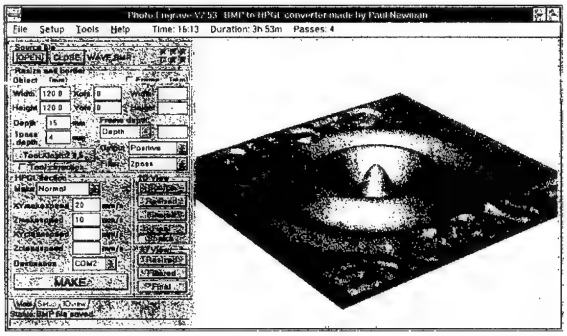
This project was made for the filling a space in controlling programs for three-dimensional (3D) engraving machines. The request was for simply program for Windows. As input data is any picture in grey-scale, a brightness of a pixel defines a depth and this 3D surface is engraved on a three-dimensional engraving plotter.

The engraving is made in a raster, the size of this raster is defined with a tool peak. Source picture is resized to the raster from entered dimensions of the product, one pixel is one step of the engraving machine. It is possible to add a frame round the product and invert the picture for the making a negative form. Than the picture is filtered with an average filter for the cleaning the surface of the product.

In the next step it is important to make a correction of data for the engraving tool. 3D model of the tool is made after a selection from a tool library. You can display the product in every step of a data preparation in three-dimensional view, it is good for a review the visage of the product.

Follow a conversion of data to the HPGL code. You must enter the depth of the product and maximal depth of one pass engraving, the engraving is made in layers, it is important for hard materials. You can enter engraving and moving speeds and mode of the engraving - Final, Rough or Cleaning.

The final program was presented on exhibition Publicity 98 in Prague and International Fair of Commercial Technologies - INVEX Computer 1997 in Brno (Czech Republic).



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Contour and Image Compressions Using Zonal Sampling and Piecewise Linear Transform

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Keywords: Image Analysis, Signal Processing, Data Compression, Transform Coding, Discrete Transforms and Applications

ABSTRACT

In this paper, contour and image data compression method based on sample selection in the Piecewise-Linear transform domain is presented. The contours are extracted from binary images using one of the known contour extraction methods. The contour and image are subjected to a two-dimensional Piecewise-Linear transformation and some coefficients are selected using treshold method and a proposed zonal sampling method. In the proposed zonal sampling method all samples outside the selected zone will be discarded completely (no zeros are replaced). The inverse transformation in this case will have a dimension equal to that of the selected zone. Thus the number of computations needed for the inverse transformation is reduced. The Peak Signal-to-Noise Ratio (PSNR) is used as a measure of quality of the reconstructed images. Some examples of compressed and reconstructed contours and images are shown. Comparisons of the compression ability using Piecewise-Linear transforms and some selected orthogonal transforms like Walsh, Haar and Cosine transforms are given. The results obtained by using the proposed zonal sampling method show that the Piecewise-Linear transforms have a better performance than the orthogonal transforms.

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SIRES IEEE CSS GREEK CHAPTER MobiNet MOBINET

Effective Image Expansion Using Subband Filterbanks

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Summary

In significant areas of image analysis, such as medical imaging and processing of satellite or reconnaissance images, is required accurate image expansion. Common magnification methods, based on linear interpolation and various cubic spline functions result in images which appear rather blurry or contain artefacts.

In this paper is presented a nonlinear approach which will preserve details and other important information of expanded images. The expansion problem is placed into a statistical framework using maximum a posteriori (MAP) estimation in the Huber-Markov random field model [1].

The main contributions of the proposed scheme are:

1. The use of an accurate modeling of the transition from low to high resolutions which is based on subband filter representation. Subband decomposition with optimal filterbanks [2] result in optimal representation of images because of the reasonable correspondence to the image content. The transition to another resolution level is optimal with the use of low-pass filtering with normalized cut-off frequency equal to 0.5.
2. The implementation of the resolution enhancement procedure via fast, still optimal, linear filtering operations. Replacement of equations with multiplication of matrices by relations based on convolution form result to important reduction of implementation effort. Earlier approaches [1] based on the same statistical framework are difficult to implement because of their computational complexity.

Extensions of the presented methodology to the problem of video resolution enhancement are outlined by the end of the paper.

The performance of the proposed scheme is illustrated in this paper using simulated experiments. Images expanded via the proposed algorithm are compared to the results of other expansion methods. Quantitative results, in the sense of mean square error (MSE) illustrate the capability of the proposed method.

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Adaptive NLP-driven systems:
acquisition of linguistic information for Informaton Extraction purposes

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Lexical knowledge is often hard to compile by hand, and even harder to port and reuse. NLP application systems still have a low impact on real world problems, mainly due to the costs related to reusability and customization of the required lexicons. In particular, changes in the domain often causes changes in required lexical information. Empirical, symbolic machine learning methods can be perfectly suited for this task like automatic acquisition and adaptation of this knowledge.
A variety of techniques seems to be combined in order to successfully design realistic inductive systems for text processing: the target of this kind of research is to define methods and design principles for systems combining linguistic and lexical learning capabilities for large scale language processing tasks. This is what we mean with adaptive NLP-driven systems.

The access to large data sets and different kind of information, that are even increasing over time (due to the telematics facilities available nowadays), requires to add inductive capabilities to NLP system for tasks related to applications as Information Extraction.
We need to define adequate models for shallow lexical knowledge acquisition and suitable integrated architectures.
With respect to a lexical phenomenon X, that seems useful to some IE tasks, we need to know at least if it is learnable from the available (domain specific or not) source and what kind of lexical inferences is supported by information on X.
Lexical information useful for IE tasks includes two main components: a foreground lexicon that refers to those specific words able to trigger certain IE actions (thus including explanatory knowledge that supports complex inferences), as opposed to the remaining words, the so-called background lexicon. Examples in this area are empirical learning of tasks like POS tagging, induction of grammatical information, symbolic learning of word sense disambiguation criteria.
In this paper the architecture of a system integrating lexical acquisition capabilities within an IE framework will be described.
Main attention will be put in describing CARET, a system that supports the semi-automatic development of lexical rules for word contextual roles recognition. CARET has been fully implemented and tested over application domains in English and Italian.

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Computer-aided analysis of multilingual patent texts

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Keywords: corpus linguistics, multilingual LR, sentence alignment, terminology extraction, translation

A multilingual text corpus, that is a collection of texts translated into several languages, provides a major source of linguistic information useful for translation. In particular, it provides information about technical terms. The acquisition of bilingual lists of terminology expressions is difficult and time consuming. It is, therefore, worthwhile to investigate methods to compile such lists as automatically as possible.
This paper deals with the development of methods to process a multilingual corpus. The developed methods result in a semi-automatic tool that helps professional translators and terminologists not only to identify technical terms, but also to detect possible translation equivalences and typical contexts of terms.
A trilingual (English-French-German) corpus of 12 million words of technical texts was used as basis for the present work. The corpus comprises about 1000 decisions of the board of appeal of the European Patent Office (EPO). Such a decision is written in one of the three languages and then translated into the other two.
The processing of the corpus comprises four steps:
1) Alignment of the texts at the sentence level
2) Definition of technical terms with criteria that are suitable for an automatic procedure
3) Extraction of technical terms. Although the preliminary work was carried out in all three languages, the extraction of candidate terms, however, was limited to subcorpora of German and French texts.
4) Presentation of results

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Parallel IE Systems for Multilingual Information Gathering

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Tourism represents an ideal exploitation field for both multilingual language technologies and Information Extraction technologies. On the multilingual side, it is clear that the touristic market is "by definition" a multilingual market, as travel and holidays are usually planned to take place in foreign countries. Also, it represents an ideal field of application for IE technologies, as the domain is limited enough, and the information seeked by the user can often be represented in the format of a frame or template.

MIETTA is a EU project in the sector of Language Engineering (LE4-8343) which represents a prototypical application of IE techniques in a multilingual context. In practice the system will allow users to consult multilingual touristic databases (for the time being English, Finnish, German and Italian) using their own language, receiving back short summaries of the matching documents in their own language, irrespective of the language of the source documents . This result is achieved by exploiting a mixture of IE and Natural language generation techniques. First, the contents of all the interesting sites and dbs are analyzed by a multilingual Information Extraction System (produced by University of Helsinki for Finnish, CELI for Italian and DFKI for English and German) and reduced into a set of language independent templates which are stored in a central db. When a user addresses a query in a given language, the relevant information extraction system processes it in order to obtain a query template. This is matched against the ones in the central db and the system retrieves a set of templates with associated documents. The documents encoded in the same language of the user are simply reported through a special presentational strategy which highlight the part of the document which matches best the query template. The documents which are encoded in a language unknown to the user undergo a process of template generation. In practice a short summary is built in the same language of the user, having as a source level the set of templates associated to that documents and stored in the central db. In this way the user can have a clear idea of the contents of the document and, in the best case, exploit the information contained therein, without having haver seen the original source.

Clearly MIETTA represents a prototypical system where multilingual IE and multilingual template generation cooperate in order to provide the user with the best snapshot of the information s/he is interested in. If this mixture of technologies will prove to be easily extensible to new domains, it will probably represent a viable alternative to standard systems of multilingual information retrieval.

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Information Extraction Techniques for Multilevel Sentence Matching

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The matching of user defined sentences or fragment of sentences against a given text is a typical problem for many NLP applications. Two instances of this problem are represented, for example, by the matching of translation memories onto a text to be translated and by the matching of a query in a textual database.

We propose an approach to sentence matching which uses information extraction techniques, exploiting the fact that one of the goals of information extraction processing is to reduce the amount of "irrelevant" information in order to retrieve the most relevant structure in a text. Thus, if both the text to be located and the text to be browsed are properly processed, we expect to achieve better matchings from the point of view of both recall and precision.

Concretely, we adapted resurces already available in IUTA, a system of information extraction for Italian. The system is based on a set of pipelined modules, which progressively refine the input texts in order to extract domain dependent templates (cf. Bolioli et al. 1997a,b, for a description and more references). IUTA modules include a text analyzer (for tokenization and recognition of named entities), a morphological analyzer (which as a side effect performs lemmatization), a Part of Speech Tagger (based on Brill (1994,1997) algortihm, with an application module as designed in Roche and Shabes (1997)), a chuncker (which creates non ambiguous, non recursive syntactic constituents), a functional analyzer (which extract basic predicate-argument structures) and a domain dependent module (which applies set of rules in order to perfom domain dependent inferences and real template extraction).

As described in (Bolioli et al. 1997c), all the modules but the last one have been designed in order to ensure domain independence so that they can be easily reused in different systems.

In the sentence matching system, we take advantage of the processing performed by the morphological analyzer, the chunker and the functional analyzer (the preprocessor and the POS tagger are included in the system as well, but they are not relevant for the matching process). Assume there are n sentences (S1, S2, ...Sn) to be matched against a text T and assume four levels of possible matching (string, lemma, chunk and predicate-argument structure). A sentence S1 will match a target sentence St in T if the multilevel finites state automaton generated by S1 can traverse St. The multilevel FSA asociated with S1 is the composition of the automata generated by S1 at each representation level. In practice, S1 generates an automaton that first tries to traverse St through string matching. If string matching fails, the automaton at the higher level is triggered, that is the automaton generated by the lemmatized representation of S1. If also this automaton fails, a matching per chunks is started,

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where only identity of each chunk's head is looked for. Finally, a matching of predicate-argument structure is tried, as a last resort.

Notice that the central idea is to allow the most precise traversing of St, given S1. So, if some segment SG of St (determined by decomposition of St into chuncks) has been correctly analyzed at some level m and the analysis fails on the following segment SG+1, SG+1 is analyzed at level m+1. If the level m+1 succeeds, control is returned to the lowest level of analys, which continues from SG+2. In this way we are able to implement a rather accurate matching function which enables us to properly rank the retrieved texts.

Since a problem of efficency arises when a large number of sentences is to be matched against the text (such as in the case of translation memories), we implemented a module which, at compile time, first collapses all the multilevel automata generated by all the members of the translation memory into a single non deterministic FSA, and then it simplifies it into a deterministic FSA with better efficency properties.

In conclusion, our work shows how the modules of an IE system can be reused in order to build both user tailored advanced information retrieval systems (e.g. when the user wants to retrieve a set of sentences from a big textual database) and multilingual systems which browse the text returning translations for all the sentences specified by the user.

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Named Entity Recognition from Greek Texts: the GIE Project

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During the past decade, substantial progress has been made in developing reliable Information Extraction (IE) technology. However, the existing IE technology concerns widely spoken languages and mainly English.So far, according to our knowledge, there is not any IE system for the Greek language, although there is activity in the area of language engineering in Greece. Our laboratory is currently participating in two IE projects, the EU-funded project ECRAN (LE-2110), and the bilateral (English-Greek) project GIE (Greek IE). In GIE we cooperate with the University of Sheffield aiming to adapt the Sheffield IE system into the Greek language. The expected benefits are the development of the first Greek IE system as well as the support of the efforts of Sheffield research team in their objective to produce a multilingual IE system. GIE started at June 1997 and has a duration of 2 years.

An IE task involves mainly two sub-tasks: the recognition of the named entities (e.g. persons, organisations, locations, dates) involved in an event and the recognition of the relationships holding between named entities in that event (e.g. personnel joining and leaving companies in management succession events).
In this paper, we present the prototype named entity recogniser we are currently developing for the Greek language, in the context of GIE. The named entity recogniser involves the following modules: lemmatiser, sentence splitter, part of speech tagger, gazetteer look up, name matcher and coreference resolution. So far we have developed the first three modules and we are currently working on the adaptation of the English gazetteer lists (names of persons, organisations, locations) and named entity rules to the Greek language. The GIE prototype is being developed over the language engineering platform GATE of the University of Sheffield. It will be tested on a corpus of management succession events (about 120.000 words), which was provided to us for research purposes by the Greek advertising company "ΔΙΑΦΗΜΙΣΤΙΚΗ ΕΒΔΟΜΑΔΑ"

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Question Answering and Information Extraction from Texts

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ABSTRACT: The present paper presents a method for the combination of question answering with information extraction and its application to texts from different domains among which are scientific texts and an ancient greek legal text. A system based on this method and implented in Prolog that uses a question grammar combined with a text grammar is used for the demonstration of the method. These two grammars use syntax rules and domain dependent lexicons while the semantics of the question grammar provides the means of their combination. The semantics of the question grammar are expressed in terms of combinations of templates or scenaria that are processed by the text grammar. Implicit semantic relations occuring either in the questions or in the texts are made explicit with the use of domain knowledge. Inference of implicit facts is performed directly from the text. The text syntactic analysis performed by the system that was implemented is based on an original parsing method appropriate for languages with relatively free word order like Greek. This method consists of the automatic translation of every sentence into a number of logical facts written in Prolog and the recognition of syntactic constituents as logical combinations of these facts. These facts take the form of a logical predicate with three arguments. The first argument specifies the number of the sentence, that contains a given word, the second argument specifies the position of the word in the sentence and the third specifies the word itself.The template approach relies on a predefined user model which guides the exctraction of information and the instantiation of a template as the result of the extraction process. Our question answering based approach aims at the creation of flexible information extraction tools which accept natural language questions and generate answers that contain information extracted from text either directly or after applying deductive inference. Another point of our method concerns the direct logical processing of text avoiding any kind of formal representation when inference is required for the extraction of facts not mentioned explicitly in the text. The examples of application presented show that the system exhibits sufficient flexibility that facilitates adaptation to the needs and the language of different users.

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Eliciting Terminological Knowledge for Information Extraction Applications

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Abstract

In this paper we present a method aiming at (semi-)automating the process of eliciting domain specific lexical resources, terminological resources, in the framework of information extraction applications. The method aims at linguistically processing machine-readable text corpora and extracting lists of candidate multi-word terms of the domain, that would then be validated by domain experts. The method proceeds in three pipelined stages: a) morphosyntactic annotation of the domain corpus, b) corpus parsing based on a pattern grammar endowed with regular expressions and feature-structure unification, c) lemmatisation. Candidate terms are then statistically evaluated with an aim to skim valid domain terms and lessen the overgeneration effect caused by pattern grammars. This hybrid methodology was tested on a software manual corpus, that consisted of 4512 unique wordforms extending to 35726 word occurrences. The list of candidate terms was evaluated against an index list of 214 terms attached to the corpus. The pattern grammar extracted 124 correct terms, featuring a 58% recall. Out of 10 different statistical filters applied only on two-word terms, the best performing one further confirmed 30% of the index two-word terms and also reduced the size of the proposed list to 1/15.

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Using Information Extraction for Knowledge Entering

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Many expert systems need a lot of data. This point has early appeared to be a bottleneck for the growth of AI applications. A major way to provide an expert system with knowledge is to enter it by hand. For instance, the huge database of the Cyc project has mainly been built by numerous knowledge enterers. With the maturity of Natural Language Processing (NLP), a new way has been opened with automatic information extraction from text.

This paper shortly presents a decision support system, named Sape, connected with an IE system. This application is used by Caisse des Depots et Consignations (CDC) in order to anticipate takeover bids on the European stock markets. It provides ways to manage the highly complex and moving network of European shareholdings (including reciprocal and cross-shareholdings). For instance, it enables to trace, through a graph oriented representation, the paths of control between companies. Sape is available on the CDC group's intranet and is operationaly used by portfolio managers.
The paper also describes how our NLP system, Exoseme, uses the economic flow of dispatches from the Agence France-Presse (French press agency) in order to extract information on shareholdings and how this information is managed by the user to provide Sape database with the large amount of figures and company names needed for its computations.

After months of use, IE has appeared to be a powerful concrete solution. Moreover, if the economical value of takeover bids has lead us to pay particular attention to shareholdings, this approach can be extended to other events such as nominations of boards of directors etc. In fact, IE allows new possibilities for portfolio decision support systems which, in turn, imply adaptations of the IE system. This paper presents the improvements we plan, and discusses those, though tempting, that are
still out of reach for the lack of adaptative tools.

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Using Functional Style Features to enhance Information Extraction from Greek Texts

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Abstract

Current Information Extraction (IE) systems extract, in most cases, fixed information from documents. Providing these systems with the capability of locating stylistic features in a text and thus detecting its genre, they will be able to meet specific user interests, i.e. user interests based on specific facts extracted from the documents and not only on the documents themselves. For instance, people are often looking for texts with particular, quite narrow generic properties: authoritatively written documents, opinion pieces, scientific articles, and so on.

The presented work is strongly motivated by the need of modelling functional style (FS) as well as categorising unrestricted texts in terms of FS in order to attain a satisfying outcome in style processing and thus in IE applications. Towards this end, it is given a three-level description of FS that comprises: (a) the basic categories of FS, (b) the main features that characterise each one of the above categories, and (c) the linguistic identifiers that act as style markers in texts for the identification of the above features. Special emphasis is put on the problems that faces a computational implementation of the aforementioned findings as well as the selection of the most appropriate method (e.g., fuzzy rules) to achieve better results on text categorisation. Finally, it is shown and discussed how the results on text categorisation can be used in information extraction applications to make current IE systems more adaptive to user needs.

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VISION-BASED CONTROL APPROACHES FOR TRAJECTORY CORRECTION OF MICROROBOTS

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Abstract: Micromanipulation has become an issue of primary importance in industry and biomedicine, since human manual capabilities are restricted to certain capabilities. The manipulation of biological cells or the assembly of a complete microsystem composed of different microcomponents are examples of the application of piezoelectric-driven microrobots. An automated microrobot-based micromanipulation desktop-station is being developed by an interdisciplinary group at the University of Karlsruhe (Figure 1). The assembly takes place in the field of view of a light optical microscope.

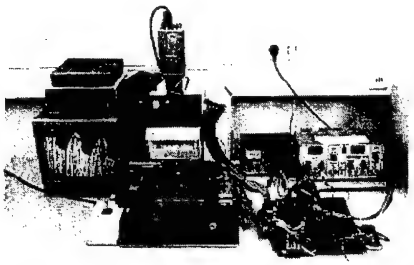

Figure 1: The automatized micromanipulation station (University of Karlsruhe)

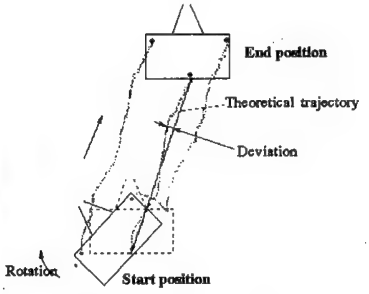

Figure 2: The inexact motion of the microrobot along the calculated trajectory (recorded by the global CCD-camera)

The paper focuses on motion control problems of the microrobots (Figure 2). The ability of an intelligent microsystem to adapt itself to the process requirements is of great importance, especially for assembly robots. The microrobots must be able to operate in a partially defined environment and must be able to handle in unpredictable situations. A neural control concept based on a reference model approach is being proposed as a solution. It can be shown, that the neural controller is able to learn the desired behaviour. This device considerably outperforms an analytically designed linear controller. This was demonstrated both in simulation and in the real environment.

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STEREO IMAGE PROCESSING AND VIRTUAL REALITY IN AN INTELLIGENT ROBOT CONTROL SYSTEM

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Abstract

This article describes the stereo vision and virtual reality module of the intelligent control system of the PUMA 560 robot and the dextrous hand developed at the Technical University of Budapest. The aim of the vision system is to provide information for the virtual reality and path planning system about the environment. The high-fidelity virtual reality has great significance, because the decisions of the operator of the robot are mainly based on visual information.

In the system uncalibrated cameras are used to acquire visual information. From the point correspondences determined by correlation technique the projective system is built. Since robotics usually requires metrical type information hence a model database is used which consists of 2D (view type) and object relative 3D (Euclidean type) information about the features of the possible objects. An object recognition method based on this database was developed in order to localize objects in the images and involve the object relative 3D information. The object recognition method uses stochastic model matching. The matching technique needs the calculation of the transformation between views which is solved by Kalman filter technique. The object recognition is also useful because the robot needs not only the metrical structure of the surrounding world but also information about the type of the objects in the environment especially for object grasping.

The output of the stereo system is the type of the recognized objects and the 3D Euclidean transformation between them. The calculation of the 3D transformation is achieved in two phases. The first one is the calculation of the collineations between object frames and the common projective system. This can be done by using linear LS estimation if sufficient number of points are known. The second one is the calculation of the homogeneous transformation between any pair of the object frames that is calculated by using quaternions. Nonlinear iteration steps based on Levenberg-Marquardt method were developed for final refinement.

The aim of the calibrated virtual world is to model the robot and its environment in real-time. The accuracy of the virtual world can be improved by the information coming from the stereo vision system. The camera-calibration for the virtual reality is based on 2D and 3D information of selected point features. The camera model is used to fuse the virtual robot and the original camera picture. The safety of the robotic control tasks was enhanced by collision detection algorithm. The above methods have special importance in telerobotic tasks, where the robot and the operator are separated by some distance and there is a communication delay between them. The use of virtual reality techniques provides important help for this issue.

Keywords: Stereo vision, uncalibrated cameras, Euclidean reconstruction, virtual reality.

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Kinesthetic Feedback on the Human Hand for Haptic Interaction with Virtual Environments: Design and Control Issues

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ABSTRACT: This paper presents a haptic interaction system for Virtual Environments (VE), integrating kinesthetic feedback for the human hand (fig. 1). The system includes a force-feedback exosqueleton glove developed in our laboratory as a hand-master device. Resistance torques are applied on each individual joint of the human hand, during active finger-flexion motions. This constitutes what we call hand-distributed kinesthetic feedback.

Two main problems are dealt with in this paper. Firstly, ways for computing appropriate feedback forces are presented, which are based on solving a load distribution problem on the contact-forces space of a virtual grasp. Secondly, the particular problems regarding the force/impedance control and stability of a haptic device, interacting with a computer-generated graphical environment, are discussed. The main feature of the proposed control architecture is the decoupling between the computer animation and the force servoing loops, using an intermediate representation. This representation is based on an exchange of information concerning the state of the prehensile actions performed within the VE (for instance, contact configurations, virtual stiffness etc.), instead of direct virtual force feedback. Experimental results are presented for the evaluation of the system's performance, in terms of control and haptic perception objectives.

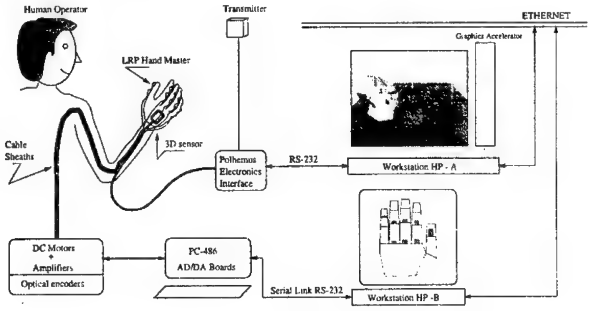

Figure 1: Hardware arcitecture of the experimental system

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Design of an artificial brain in a tracking and recognition robot

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ABSTRACT

This paper presents the structure of an artificial brain in a tracking and recognition robot. The artificial brain, which is a new information processing and control system hardware, consists of two RICOH neurocomputers RN-2000, NEC PC-9801 computer, and interfaces. Recently we have already developed a primitive artificial brain, which consists of one RICOH neurocomputer RN-2000, NEC PC-9801 computer, and interfaces, in order to track a moving object by using the CCD camera. In this system, the robot is not able to recognize the moving object due to the hardware structure devised. The new robot system is able to recognize the moving object and to track it. At first the moment invariants of the moving objectare calculated in order to recognize the shape of the moving object and then track it using the trained neural network constructed on the RICOH neurocomputer. The neural network used in the recognition has four layers structures. The input layer has 15 neurons, the first and second intermediate layers have 16 neurons, respectively, and the output layers has 5 neurons, which is equal to the number objects to be recognized. For tracking the moving object, the four layers neural network was used. The input layers has 4 neurons, the first and second intermediate layers have 16 neurons, respectively, and the uotput layers has one neurons. The experimental studies are illustrated in this paper in order to show the fundamental functions of the artificial brain for the recognizing the object and trascking it in the robot.

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Modelling and Control of a Visual Servoing System

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Abstract.

In the present paper, the modelling and control of a visual servoing system is presented. The main different approaches to face this visual servoing problem are presented. Among them, the position-based approach is chosen. In this approach, the features extracted from the images are used to estimate the relative object-camera position. This position is then compared with a desired relative position (used as a reference for the servoing system). The preliminary calibration procedures needed for this approach are also outlined in the paper.

As a first approximation to our visual servoing implementation, the planar case is considered in simulation and real experiments. In the general case, the six degrees of freedom (DOF), necessary to reach any position and orientation inside the robot working space, are involved. The extension to this general case is also presented, but no experimental results have been obtained yet.

The robot manipulator used in our implementation is the PUMA 560. Unlike other authors, the control commands given to this robot are not exercised directly on the joint's servomotors. Instead, the robot is commanded at a higher level, using the *ALTER* facility, in which the references to the robot are given in cartesian coordinates, avoiding the need of inverse kinematics calculations.

The portion of the model that takes in the behaviour of the robotic system will be considered as a low-level control stage. Its sampling period is fixed by the robotic system at 28 ms. On the other hand, the visual control stage, or higher-level stage, comprises the camera model, the image capturing mechanism, the position estimation algorithm, etc. The sampling period of this second portion of the model is fixed to a value between 3 and 9 times the lower-level sampling period, depending on the complexity of the feature extraction procedure. After this description, it is obvious that our system has a multirate nature.

A detailed model for the described visual servoing system is obtained in the paper. However, in order to ease the controller design process, a simplified, single-rate model is calculated. Based on this reduced model, proportional, pole placement and Smith predictor controllers have been designed and tested by simulation and in real experiments.

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INTEGRATED DESIGN FOR FLEXIBLE ASSEMBLY SYSTEM
Robotic Arc Welding stations for Containers

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ABSTRACT

The cost of the products we make are determined more and more in the design office, yet design for assembly techniques are often only used to modify component details so that they may be handled, orientated or assembled automatically.

Thus the present economic situation demands constant improvement of productivity, which is determined by technical performance and the flexibility of production plant. Usually, containers are to be manufactured on assembly lines. But for better productivity, we suggest assembly and robotic arc welding stations technic of the different bits of the containers made in the different corresponding bits workshops surrounding the station in order to maximise the efficiency of production factors.

In this paper, assembly and robotic arc welding stations are discussed and an example is given to illustrate this productivity-related concern.

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Design and Implementation of an Experimental Testbed for a Two-link Flexible Robot

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ABSTRACT: A superior-performance experimental testbed for a two-link flexible robot should be carefully designed and built in many aspects, such as mechanical structure, high-precision, fast-response sensors and electrometers, accurate data sampling and signal processing, etc. Because of the complexity and expensiveness of building an experimental testbed, it is important for researchers to make use of the experimetal testbed to research the mechanism and control approaches of the flexible-link robot. Furthermore, the relation between research approaches and the experimental testbed, and independence and opening of the experimental testbed to effectivelly develop different research schemes also should be considered.

This paper is concerned with an expeimental testbed for a two-link flexible robot built in Tsinghua University, and discusses how to design and build the exiperimental testbed, and make it easier to do research and experiment.

The exiperimental testbed for a two-link flexible robot consists of the following parts:

(1) System hardware

It is composed of flexible-link robot device, electrometers, actuators, sensors, and data sampling board, and signal processing board.

(2) Simulation subsystem

The subsystem can be used to simulate the kinematics and dynamics of the flexible-link robot, and at the same time, carry on the conrol approach reseaches and model verification etc.

(3) Control and display subsystem

The subsystem can be used to investigate the system performance of the flexible-link manipulator under different control algorithms, display the motion result of the flexible-link robot in real-time.

(4) Communiction subsystem

All parts of the system could communicate with each other, implement transmission of data, command and other information.

All these subsystem constructs the whole the experimental testbed of a two-link flexible robot. They implemet the work jointly, such as operation of practical system, system simulation and control, etc.

If the testbed of the flexible-Link robot is in Internet, reachers also could remote to have access to the system through network, and do related researches on the testbed.

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Intelligence in Computer Aided Process Planning for machining

by

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Abstract

Manufacturing process planning encompasses a number of decision domains, typically: selection of operations, machines, tools, operating conditions, setups, fixtures and operation sequence. In spite of the use of variant systems, in practice these are recognised as being restricted in scope. Generative systems are by definition intelligent, but they are also bound to refer to specific part types or families in order to be practical. This paper advocates coupling of the two approaches in terms of interactively defining a generic process plan per part family, which is then further developed according to specific parts within respective families. Within that framework the following issues are discussed, referring to examples from a major european research project to which the authors contributed.

The first issue is the need to interface the process planning decision making process to a geometric modeller. Invariably, geometric reasoning is carried out in terms of features. Feature based design by definition forms a good basis, but it is also demonstrated that feature recognition is needed in two cases : first, when the planner needs to transform the features that the designer worked with and second, when the planner needs to discover specific types of relations among features.

The second issue is the mechanism of process selection and sequencing. Although these phases are usually separated for the sake of simplicity, in reality they have to be carried out concurrently. Moreover, process selection inherently refers to setup definition, too. Control of this decision process is implemented here by a loop with intelligent feed back branches in the form of semantic nets, totally under user control. Intelligence is associated with pruning of the different possible paths in the search space, the final decision being the user's.

The third issue is representation of the factory items as well as of the manufacturing knowledge needed in decision making, such as tools and tool selection, machines and machine selection and cutting condition selection. Normally constrained sets of formulae are needed for cutting condition selection, which reflects back on tool selection, whereas machine selection is more straightforward. Frames and methods are discussed here as the most suitable representation paradigm.

The fourth issue is the interface of the process planning system to a factory scheduling system in order to achieve integrated manufacturing. The use of process planning data by a heuristic scheduling algorithm and possible ways to react to unforeseen changes in process plans are presented.

The last issue discussed is a data management and communication interface within a distributed data environment in the factory with messaging as the main focus.

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FÉDÉRALE DE LAUSANNE

CONCEPTS FOR INTEGRATING DESIGN AND PRODUCTION

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Abstract

This paper focuses on the interrelations between design and production. Our major concern is to achieve a methodology with which a better production resource utilisation can be guaranteed: how design stage could take into account the predicted production demand and what sort of information should production provide to the design stage. A method for analysing production solutions, based on the high level modelling of the production system and production demand, is sketched. The properties of the established concurrent system are identified by model checking methods: either the existence of a satisfactory schedule is proved or a refutation is created for supporting design modifications.

Keywords: Design for Manufacturing. Production Planning. System Modelling

A Study on Self-Organization in a Production Environment

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ABSTRACT

Modern distributed manufacturing systems show urgent needs for organizational control and, whenever autonomous agents are involved, needs for self-organization. Firstly, the characteristics of manufacturing systems are analyzed, that make self-organization necessary. The concept of self-organization is further studied within the context of autonomous agents participating in the manufacturing process. A specific example of flow control between independent manufacturing units or cells is then presented. In this case, the self-organization problem translates to a specialization problem for the various autonomous robots or agents regulating the flow. A specialization model capable of solving this problem is given, that is based on self-regulation of certain "motivational" parameters. Those parameters represent the agent's preferences for servicing the various units of the system. The specialization model is also studied in a more abstract way to identify and generalize the features of the flow regulation problem that ask for such a specialization model.

Keywords. Manufacturing organization, autonomous agents, self-organization, specialization, self-regulation.

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PROPOSITION OF A PRODUCT DESIGN SUPPORT TOOL

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Abstract

In the design field, most of the CAD systems and tools do not totally support the design activity because none of them helps the designer to know what to do and when to do. In addition, it is established that the informational richness of the designer's knowledge and its know-how during design steps is omitted in these tools which only document the results of design process and not the process itself.. Formal approaches to design knowledge capitalisation have only recently received attention. The major shortcoming of these approaches is a semantic ambiguity of the knowledge representing the design artefact and the design process. Our work proposes a response to this situation.

In this communication, we present a design support tool which aims is to capture the design knowledge related to a product or an artefact for further reusability in the case of re-design. We have developed a data structure encompassing a *Product Model* and a *Design Process Model*. These two models are "generic" in the sense that they are based on a set of concepts which are domain independent. Concepts are defined at a meta-level and further instantiated to represent both classes of products and processes and a product process execution steps. To allow such a model genericity, we have clearly stated three conceptual representation levels for the two models: (1) the *Meta-Level*, (2) the *Specification Level*, and (3) the *Realisation Level*. Moreover, this genericity allows the reusability of models already defined and makes the design task easy and simpler to be performed.

The ***Product Model*** is used to specify a product by means of a set of information structured in : (1) *Parameter Concept* for quantitative information, (2) *Description Concept* for qualitative information, (3) *Constant Concept* for invariant information and (4) *Behavioural Variable/Equation Concept*. We have taken into account that a product to be designed can be differently perceived by distinct designers accordingly to their tendencies and preferences. The *Viewpoint Concept*, in the *Product Model*, allows the definition of multiple views of a product.

The ***Design Process Model*** supports modelling of the different design steps in terms of a workflow language in order to capitalise the designers' knowledge. This model contains: (1) *Task Concept,* thinking that each design process is structured in a set of design tasks and a task can be an atomic or a composite one, (2) *Flow-Control Operators Concept* describing the control flow between tasks in a design process, (3) *State Concept* allowing the capture of both statuses of the design process and the task, and product evolution statuses during process enactment, and (4) *Resource Concept* describing the set of tools used in the design process, like drawing software packages, calculation or estimation algorithms, simulation tools or 3D modelers, etc.

To validate our approach, we have developed a software prototype on PC by using the object-oriented language SMALLTALK and the VisualWorks 2.5 environment for the user interface development. This prototype is being used to represent the design activity in the electrical field by simulating the design process of an asynchronous electrical engine.

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Single and multimachine scheduling of jobs in production system

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A set of jobs available at time *0* should be scheduled in a Workshop which consists of different types of devices for the producing different products.

Formulation of the single machine scheduling

For the formulation of this problem it is considered a *W* with j_z, $z = 1,2,...,n$ jobs for $h = 1,...,p$ products. Characteristics of *W* are as follows: various types of workpieces and halfproducts are ttransported by a palette on the quided vehicle (AGV), according to the technological process (TP), to the corresponding producing devices, where the processing time depends on the particulas production task.

The task may be formulated as follows: to find the time based service model of producing devices and the algorithm of AGV scheduling. For the solution of such single machine scheduling problem it is supposed a „time window" which separate the completion of job j_z and beginning of job j_{z+1}, which may be determined constraints by $k_z \geq 0$ and $K_z \geq k_z$, which express the maximal and minimal separation between jobs j_z and j_{z+1}.

For the solution of so formulated problem is possible to use the heuristic algorithm with combination of adaptive principle in the case if it is appeared an undesirable event and the AGV is unable to perform the required job in available time.

Multimachine scheduling of jobs in PS

The approach described in above is possible to use also for the case of multimachine sheduling with formulation as follows:

Let be J_i the set of different kind of jobs, $i = 1,2,..., l$.

Each set J_i contents *n* jobs $j_z \in J_i$; $z = 1,2,...,n$.. The production process (PP) of *h* - products contents a set $F_h \subset J_n$ created from different kind of jobs, $F_h = \bigcup_{i=1}^{l} F_i$ where each set contents $r_i \in F_i$ number of jobs. The following constraints are considered:

constraints of initial conditions, constraints conjuctive and constraints disjunctive for the case if jobs are from different set of J_i.

The aim of the solution

To determine such configuration of jobs set F_h performance verifiyng all constraints, that the total time *T* of performance will be minimal.

The algorithm of this approach will be described in the paper.

ANALYSIS AND RECONFIGURATION OF A PACKING PRODUCTION PROCESS IN AN ALIMENTARY PASTA FIRM

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ABSTRACT

This paper presents a methodology approach applicable to the study, the project or to the reconfiguration of a production process, on which are highlined flow problems between the different parts of the system.
In particular it had been analysed the final packing department of an alimentary pasta firm, it had been developed a logical-mathematical model that describes the behaviour of the system, for its development a discrete event numeric simulation was used.
As a consequence to the analysis of the model, some critical activities for the process had been highlined and there had been proposed some solutions in order to improve the productivity of the process, by improving the logistic aspects.
The results of those solutions were evaluated whit the simulation model, allowing, in this way, a comparison between the different proposed solutions and determining the new configuration of the process, useful in maximising the product flows interested.

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Build-Time Estimation Tools for Rapid Prototyping Stereolithography Systems

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Abstract

A few years ago a new group of techologies made their appearance in the growing field of Advanced Manufacturing systems, the so called Rapid Prototyping & Manufacturing (RP & M) techologies or better Layer Manufacturing techologies. As the above definition denotes all the members of this group share the same basic operational concept which is to build parts from various materials (polymers, metals, paper etc.) in a layer-by-layer basis, without the use of any kind of manufacturing tools and almost directly from CAD data. The above features combined with the high degree of automation employed in these systems and the small amount of time required for production made RP & M systems an attractive solution for a great deal of applications in the automotive, aerospace and consumer products industry.

Stereolithography, a process which builds objects by successive solidification of polymer resin layers, was the first to open the road of wide adoption for the RP & M technologies at the beginning of the 90's. Among the several research issues, which emerged with the gradual expansion of installed Stereolithography units, was the trade-off problem between fabrication quality and fabrication cost. Cost for Stereolithography and for most of the RP & M technologies, is a function of time required for the complete fabrication of the parts. Therefore prediction of the amount of time required for the completion of certain "jobs" or "builds" (batches of products fabricated at the same time) is of critical importance.

More precisely, "build time" (denoting the amount of time required for the fabrication of the part inside the system) estimation is useful for the decision making processes which preceed fabrication, like optimum placement of parts inside the build space, selection of build parameters for the fabrication and obviously job pricing and scheduling. Especially for job scheduling, build-time estimation is very important since Stereolithogrphy systems are relatively highly automated (no human supervision is usually required) and the fabricated parts are usually of unique nature (prototypes or models).

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For the build-time estimation several parameters concerning the system, the material, the build style and the geometry of the part should be taken into account. While appropriate values for the first three groups are fairly easily specified by the operator of the system, the ones depending on the geometry of the part, require some computer processing. Geometry information of the part is usually provided either in the form of STL files or in the form of layer files. The first type is the *de facto* standard for the communication between CAD and RP systems and employs tesselated triangles in order to describe the outer surfaces of the part. Layer files on the other hand include basically the 2D description of all the layers composing the part.

The purpose of this paper is to investigate the degree of accuracy of the above approaches and also to identify their limits. Two software tools were developed after extensive study of the Stereolithography system (STEREOS Desktop S) installed at the University of Piraeus, including its basic operational subsystems like the laser scanning and the resin recoating mechanisms. The results of this study, the basic geometric concepts underlying both approaches and the software implementation are covered in the first part of the paper.

In the second part of the paper, the results of the practical use of both tools for build time estimation are presented and discussed. It is shown that both tools are reliable. The tool relying on STL file information is relatively faster but not very acurate in certain cases. On the other hand the layer files tool is more flexible and very accurate. In agreement with other investigators, the basic source of inaccuracy in the build-time estimation is the accurate prediction of the laser power during fabrication. This source of error is common for both approaches and makes the exact estimation of build-time a rather impossible task.

It is concluded that a further study of the laser scan mechanism and its operational features, as well as a more complete and comprehensive study of the He-Cd laser behaviour could greatly enhance the accuracy of build-time estimation tools and in general, the optimum use of Stereolithography systems.

A Supervisory Technique to Control a Two Level Assembly System

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ABSTRACT: This paper addresses a supervisory technique in a two level assembly system. The flow control addressed in this paper belongs to the highest level of the hierarchy usually proposed to model a manufacturing system. The basic idea of this general approach is to consider decisions and events at different levels of a hierarchy according to their frequencies. We consider a deterministic system and the objective is to obtain an optimal control policy for each machine in this system. The optimal control policy is used then to design a supervisor in order to make the assembly system to follow the optimal flow control policy as close as possible.

A two level assembly line is composed of a unique assembly machine, and several upper level machines. Firstly, components are produced by the upper level machines and stocked in the buffers associated with the machines. Each machine has a maximal production rate (or capacity). The demand is known over the hole problem horizon. The flow control problem consists of adjusting the production of the machines in order to minimize the total cost incurred by holding components and finished products. We firstly addressed the case of the single machine problem, then the case of a transfer production line, in order to establish the characteristics of the optimal control policy which are needed for solving the general case.

The paper has two important parts: (1) design of the optimal control policy for the two level assembly system and (2) synthesis of a controlling supervisor designed in order to obtain an imposed closed loop behavior for the assembly system with a set of optimal control policies for each machine.

The flow control of an assembly system is not a trivial problem. Some naive control policies are not optimal. The characteristics of the optimal control policies hold to the conditions under which an optimal control policy can be obtained. The goal is to design a simple algorithm for computing the optimal control policy.

The optimal control policy once determined, the assembly system has to follow it, as close as possible. The system to be controlled is seen as a discrete event system. The supervision for this two level assembly system implies the capability to enforce some constraints such as to avoid some situations or strings of events. Those states from which the system will evolve uncontrolled to some prohibited situations must be avoided. The objective is to design a supervisor with a marked behavior in order to obtain a desired behavior of the closed loop system.

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An Adaptive Neuro-Fuzzy Inference System (ANFIS) Approach to Control of Robotic Manipulators

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Abstract. In this paper, Adaptive Neuro Fuzzy Inference System (ANFIS) is used for the controlling of a commercial robot manipulator. A Microbot [1] with three degrees of freedom is utilized to evaluate the proposed methodology. A decentralized ANFIS controller is used for each joint, with a Fuzzy Associative Memories (FAM) performing the inverse kinematics mapping in a supervisory mode. The individual fuzzy controller for each joint generates the required control signal to a DC servo motor to move the associated link to the new position. The simulation experiments indeed demonstrate the effectiveness of the proposed method.

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Fuzzy Behavior-Based Control with Local Learning

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ABSTRACT: Recently, studies on an intelligent control are attractive in a field of robotics. A major approach is the behavior-based control with the subsumption architecture. If the method is applied for a robot, then the robot behaves itself like a life having an intelligent. The method divides a task into several behavioral elements. The final control input is a signal consisting of a fusion of the outputs from each behavioral element. The above method is usually realized in a hardware, so that a designer must schedule it in advance; it is not easy to change the strategy online.

On the other hand, there are some intelligent methods introduced in soft computing technologies. A fusion method between behavioral elements is expressed by a neural network. It is called a behavior net approach. Another approach is proposed as a structured intelligence that is constructed by several layered knowledge, in which the learning of knowledge is achieved by a virus evolutionary genetic algorithm (VEGA).

The present authors have already proposed a fuzzy behavior-based control system which is realized as a soft-computing. The system is fundamentally similar to that due to the subsumption architecture, but it has a competition or cooperation unit consisting of a saturation function to generate a suitable consequent result. The simplified fuzzy reasoning is assigned to each behavioral element with a single input-output relation. The mean value and inverse value of standard deviation for a Gaussian membership function, and a constant value in the conclusion part are learned by a genetic algorithm (GA). Thus, the total parameters associated with a fuzzy controller are encoded within one chromosome, like a Pittsburgh approach. The obtained objective knowledge is expressed as a total system, but each behavioral element is not expressed enough by fuzzy rule.

In this paper, we propose the fuzzy behavior-based control system with a local learning to get a knowledge of each behavioral elements. The method will have the robustness against an environment change. The effectiveness of the present method is illustrated through a simulation example for the acquisition of an objective point, with an obstacle and an environment surrounded by walls.

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Impedance Control for Multi-DOF Manipulator by Learning-Based Fuzzy Environment Models

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ABSTRACT: Most of industrial robots are employed in relatively simple tasks such as spot welding, spray painting, and pick and place operations. In such tasks, position control is very important because the manipulator must follow a trajectory through space. However, a force control is necessary when any contact situation is appeared between the end-effector and the manipulator's environment. Compliant and precise force control of manipulators in the face of uncertainties to their work environments is a prerequisite for application of robot manipulators to grinding, sanding, polishing and so on. Impedance control is known to be one of the most effective force control methods for a robot manipulator being in contact with an object. It should be noted, however, that a practical approach to such a method has not been successfully applied to an industrial robot with 6 degree-of-freedom. Recently, a hybrid compliance/force control (HCC) in this field was studied to deal with a practical task, in which a desired damping coefficient is determined by repeating many simulations, or by trial and error. To determine a suitable compliance without trial and error, we have already introduced a tuning method that produces the desired time-varying compliance, giving the critical damping in contact with an object, by using the physical parameters of the object. Related simulation results have also shown that the proposed method was very effective for deciding the desired compliance without complicated tuning. But this method has to know the physical parameters of the environment to calculate the desired compliance.

In this paper, to overcome this problem we further propose a position-based impedance control using fuzzy environment models. Fuzzy rules which constitute the fuzzy environment models are learned with genetic algorithms. By introducing the fuzzy environment model, it is possible to estimate the stiffness of environment and to yield the desired compliance which suppresses the overshoots and oscillations. Simulation results show that the proposed method using this desired compliance can accomplish the stable force control even if the environment is unknown. Furthermore, it has been recognized that the proposed method is very robust to the unlearned environments, which have different qualities in each direction, by synthesizing and reusing the fuzzy environment models learned in several fixed environments.

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ROBOT ADAPTIVE CONTROL BASED ON NEURAL NETWORKS AND FUZZY SELF-TUNING SYSTEMS

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Abstract

The tracking control problem of robotic manipulators has been widely investigated with many different techniques already developed. Parametric uncertainties and external disturbances make necessary the use of robust and adaptive control schemes. Increasing attention has been paid to the application of neural networks and/or fuzzy logic methods in robot control which can accommodate varying environments and which are not so sensitive to modeling errors.

This paper considers the application of neural and neurofuzzy adaptive control techniques to rigid-link robotic manipulators, and demonstrates the efficiency of self-organizing fuzzy systems to contribute in the control of coupled and highly nonlinear systems like the robots. A novel Counter Propagation Network-based fuzzy controller (CPN-FC) is used in a FELA architecture for the control of a 3-DOF robot. The hybrid control scheme adopted consists of two elements. The first element is the computed torque controller which takes into account the dynamic coupling between the robot links, while the second element is the CPN fuzzy controller which produces an additional torque signal capable to eliminate parametric inaccuracies and external disturbances. The capability of the fuzzy controller to self-construct and correct on-line its rule base, is achieved via the structural mapping of a simplified fuzzy control algorithm (SFCA) into a modified counterpropagation network (CPN). Thus , the rule base can be constructed automatically and respond successfully to the rapidly changing dynamics of the robotic model. The fuzzy reasoning mechanism can be implemented easily, and the required prior-knowledge about the robotic model is drastically reduced.

The above control scheme is compared to a more familiar neural-adaptive control structure in which a feedforward network (Multilayer Perceptron : MLP) is used to learn the inverse dynamics of each joint of the robot so as to exert nonlinear compensation to the manipulator. The neural controller is embodied in the same FELA architecture. The capability of a neural or a self-tuning fuzzy controller to restore the decoupled robotic model, initially achieved by the computed torque control and distorted by external disturbances, is revealed.

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Cooperative Control Using Multiple Manipulators with Different Command Inputs

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ABSTRACT: In order to perform several complicated tasks or skills represented by assembling, grinding, handling and so on with multiple manipulators, a lot of cooperative approaches have been proposed. There are some advantages due to multiple manipulators, for examples, the handling task of a heavy or big, or flexible object, and the realization of the high mechanical stiffness, etc. Conventional approaches are classified into the master/slave method, the force and position hybrid method, the compliance or impedance method and the dynamic method. Above approaches treat with manipulators having a same kind of control input commands. This is a problem for an industrial manipulator, because if manipulators have a different kind of command system, then we have to change the hardware of the command system as the expensive cost.

In this paper, a cooperative system is constructed by the master/slave method using two manipulators which have different kind of control inputs (torque or position). The one manipulator is a pantagraph-type with two degree-of-freedom (DOF), the other one is an industrial type which has five DOF and a six DOF force sensor. A position control is applied for the pantagraph-type manipulator which is the master, and a force control with a fuzzy compensator is applied for the industrial manipulator which is the slave manipulator. The fuzzy compensator estimates a spring constant of an object. The position command of the industrial manipulator tracking to the master manipulator is created by the output of the fuzzy compensator and the position of the end of manipulator as a stiffness control. The task is an object handling and transportation. The proposed method is available for existing manipulators without the hardware modification. The effectiveness of the proposed method is demonstrated by some experiments.

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A Stable and Robust Fuzzy Controller for the Position Control of Robots.

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ABSTRACT: In this paper we apply Fuzzy Logic Control to the regulation problem of a robotic manipulator using the theory proposed by Takaki – Sugeno. The non-linear system is represented by a Takaki-Sugeno type fyzzy model. In this type of fuzzy model, local dynamics in different regions are represented by linear models. The overall model of the system is achieved by a fuzzy blending of these linear models. Then a model based fuzzy controller utilizing the concept of parallel distributed compensation is used. The idea is that for each local linear model a linear feedback control is designed. The resulting overall control is nonlinear in general and is again a fuzzy blending of each individual linear controller. This paper deals with the stability and design issues of this fuzzy control method as applied to the regulation problem of a robot with parametric uncertainties. Parametric uncertainties are assumed to be bounded. The objective is to address both the stability and the dynamic performance of the fuzzy control system. A closed loop system matrix which governs the system behavior under no parameter uncertainties is first designed and the feedback control gains are computed so that the desired closed loop performance is achieved. A stability criterion which involves an algebraic Ricatti equation is then used and the uncertain system is shown to be stable if for the existing uncertainty upper bound there exists a positive definite solution of the Ricatti equation. This methodology is applied to a single link robot and simulation results show that the system is stabilized successfully and the system behavior is excellent. The big advantage of this controller over the conventional PD joint control for robots is that the system behavior does not depend on the desired position while the design and implementation remains simple and of low cost.

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Dynamic Control for a Holonomic Omnidirectional Mobile Manipulator

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ABSTRACT: Recent robots in automated manufacturing lines are usually required for the improvements in their working accuracy and effectiveness. A robot having several higher-level functions is capable of achieving not only a single simple task such as pick and place, but also human-like skillful tasks. The studies on a robot with both mobility and manipulation functions are now very attractive because they can contribute to the flexible automation in a factory and the assistance of a work, which requires the mobility of the robot at the inside and the outside of factory. In order to enhance the flexibility and degree-of-freedom (DOF) of the motion for a manipulator, there have been some studies on a manipulator with a mobile mechanism (hereafter, it will be called mobile manipulator). It should be noted, however, that since most of mobile manipulators adopt a nonholonomic mechanism for the mobile part (i.e., platform), the movable region of the platform must be taken into account for the setting of desired trajectory. In addition, the nonholonomic mobile manipulators have a problem that they can not retain a desirable orientation, if there is any force applied to the robot from the direction of moving constraint. Thus, the conventional mobile manipulators as mentioned above can not completely exhibit the flexibility and degree-of-freedom of the motion, which is a merit for a mobile manipulator.

The present paper describes a control system for a holonomic omnidirectional mobile manipulator, in which the holonomic omnidirectional platform consists of three lateral orthogonal wheel assemblies and a mounted manipulator with three rotational joints is located at the center of gravity (c.g.) of the platform. We first introduce the kinematic model for the mobile manipulator and derive the dynamical model by using the Newton-Euler method, where a model which simultaneously takes account of features of both the manipulator and the mobile parts is given to analyze the effect of the movement of mounted manipulator on the platform. Then, the computed torque control and the resolved acceleration control methods are used to show that the holonomic omnidirectional mobile manipulator can be controlled so as to retain any fingertip position and orientation, irrespective of the direction of external applied force. The validity of the model and the effectiveness of the present mobile manipulator are clarified by using several numerical simulations and 3D animations.

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Force Sensing in Microrobotic Systems – An Overview

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Nowadays, micromanipulations are performed using either mobile microrobots or a precise positioning device under control of an optical or scanning electron microscope. Various tools for the manipulation of microparts and the assembly of microsystems have been developed and integrated into the above mentioned systems. During the initial state of development, special emphasis was laid onto the design of different microhandling tools applicable for appointed operations. Often sensor feedback is only given by means of optical sensors, thus leading to a lack of information about the interaction forces between endeffector and microcomponents. In order to avoid breaking or damaging objects during the manipulation process, force reflection has to be assured as an essential component within the control structure of micromanipulation and microassembly systems.

A profound study in literature about force sensing in microrobotics showed that there is a distinct demand for sensors capable of measuring forces in the range of micro- or even nanonewton. In regard to its importance for the grasping of microobjects, there are not many suitable solutions offered at present, thus requiring increasing efforts within this scope in future research works.

This paper describes fundamental methods of force sensing and gives an overview about currently available applications of force sensors in microrobotic systems. Realisation of a reliable force sensing during the manipulation of microobjects is one of the important objectives of the current research activities. Very small sizes of manipulated microparts and endeffectors in µm or even nm range make it difficult to find an optimal solution in terms of accuracy, sensitivity and cost of the sensor equipment. At present, the most common technique used for force sensing in micromanipulation tasks is that of strain gauge sensors with an emphasis on semiconductor types. Other promising methods for strain measurement are also explored, e.g. a capacitive sensor or a Laser Raman Spectrophotometer. Some of the proposed force sensors use the piezoelectric or so called self-sensing effect in piezoactuators, but the sensitivity obtained so far is often poor. In general, only few work is present in literature providing a basic and analytical description of force sensors for micromanipulation tasks, i.e. accuracy, precision, linearity and resolution of the sensor system.

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SIRES IEEE CSS GREEK CHAPTER MobiNet MOBINET

ABOUT ONE WAY OF INCREASING STABILITY OF CLIMBING ROBOTS

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Abstract:

In this paper a four-legged robot intended for working processes on external surface of ships under construction is considered. Each foot of the robot has an electromagnet system for robot's holding on the external surface of a ship. This surface can be both vertical and inclined, including negative slope.

Analytical calculation of robot stability under these conditions has been made. Both possibilities of robot sliding along the surface and its turning-over are considered. It is shown that one can observe minimal reserve of robot stability when a surface on which the robot is moving has a negative slope. Critical slopes have been determined. One of these slopes corresponds to minimal reserve of robot stability towards sliding and another to minimal reserve of robot stability towards turning-over.

It has been found out that when a distance between gravity center of the robot and a surface along which it is moving, is relatively small, a reserve towards turning-over (RT) is much higher than a reserve towards sliding (RS). As total reserve of stability of a robot is always equal to the minimal one of these reserves, it is possible to increase total reserve of stability at the cost of RS increasing.

It has been shown that the use of additional support elements of elastic material with high coefficient of friction (of rubber type), along with electromagnet, allows to increase RS. When robot's leg is in a free state, additional support elements have to bulge a little out of electromagnet surface, but when a leg touches support surface, they, at the cost of their elasticity, have to give electromagnet a possibility to adhere directly to support surface without any clearance, because even minimal clearance between electromagnet and support surface leads to a fatal decrease of electromagnetic attraction force (it is just what does not allow to increase friction force at the expense of applying of special materials with high coefficient of friction onto magnet surface). The use of such support elements leads to redistributing force of normal support reaction between electromagnet (which surface has low coefficient of friction) and additional support element (which surface has high coefficient of friction). It is just what leads to increasing of total friction force and as a consequence to increasing of RS.

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It has to be mentioned that the use of additional support elements leads to some decreasing of RT, which, as it has been said before, is usually overdimensioned. A problem has been solved of a selection of optimal parameters of additional support elements. By optimal parameters authors understand such parameters which supply maximal total reserve of stability of the robot. It has to be pointed out that availability of preliminary information on possible slopes of support surface allows to make tuning of additional support elements on more high reserve of robot stability than in case when preliminary information is absent.

It is shown that by using the proposed additional elements and their right tuning it is possible to increase robot stability reserve more than 50%. In this situation it is possible to increase robot payload up to several times.

Motion planning of mobile robots under a control constraint

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ABSTRACT

We solve the Motion Planning Problem (MPP) for nonholonomic systems without drift under a Discrete Levels Constraint (DLC), namely when their inputs take values in a given finite discrete levels set. The MPP is the problem of finding reasonable algorithms producing for every pair of points $\{\mathbf{x}_0,\mathbf{x}_f\}$ an open loop control $t \to \mathbf{u}(t) = (u_1(t) \quad u_2(t) \quad \cdots \quad u_m(t))^T$ that steers $\mathbf{x}_0$ to $\mathbf{x}_f$. The DLC is a typical constraint that arises in many practical problems including the digital implementation of control policies, the hybrid control systems and the control of physical systems. An initial attempt to understand the effects of the DLC in the behavior of a nonlinear system was made by P. G. Skiadas and N. T. Koussoulas in [1], [2] and [3]. In [1] the authors focused on the controllability properties of nilpotent systems with and without drift and in both cases they proved that the MPP for the constrained system has at least one solution if and only if the MPP for the corresponding unconstrained system can be solved. Applications of this result appeared in [2], where the authors proposed an algorithm that solves the MPP for nilpotent nonholonomic systems without drift under a DLC and they proved that it provides an exact steering. The MPP for non nilpotent systems was solved in [3], where two steering algorithms were proposed. The first algorithm [3, Algorithm 2] can be applied to nilpotentizable systems, providing an exact steering. The second algorithm [3, Algorithm 3] is actually an iterated algorithm that can be applied to neither nilpotent nor nilpotentizable systems. The iterated algorithm does not provide an exact steering but steers $\mathbf{x}_0$ to $\mathbf{x}_f$ with any prescribed error. In this paper we are going to propose another method of solving the MPP for nilpotentizable nonholonomic systems without drift under the DLC. This method is

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called pseudonilpotentization method and uses tools from the differential-geometric control theory providing an exact steering for nilpotentizable systems. First, we establish the theoretical base of our method giving a number of results that prove the existence of the steering controls for the constrained system. Then we state the algorithm that realizes the proposed method and we prove that it provides an exact steering if the system is nilpotentizable. Finally, we explore the details of the pseudonilpotentization method solving the MPP for a unicycle mobile robot.

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ABSTRACT

Landmark-based robot sensor structure for the navigation

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The development of sensor systems applied to the self-navigating mobile robot units is essential in the construction of the modern manufacturing systems. These mobile robot units may have many important tasks, such as carrying the raw materials or the work-pieces between the manufacturing cells or from the manufacturing cells to the automated stock.

The navigational environment could be known or unknown for the mobile robot. In our case the navigational environment is already known. It means, that we have the full map describing the environment. We suppose, that the trajectory planning is done off-line in advance, and the calculated trajectory has to be downloaded to the mobile robot. The robot uses its own sensor system to match the stored map to the real surrounding environment, follow the pre-planned trajectory, and seek for any unexpected obstacles (i.e. other agents) to perform collision-avoidance.

In the paper we present the concept of a landmark-based navigation sensor structure in a multi agent mobile robot environment.

The sensor system contains a CCD camera, a phase modulated laser beam with random deflection unit, a photomultiplier and phase comparator for distance measurement, and a deflection angle monitoring system. All this components are cheap and robust, and they are integrated in a hierarchical measuring process.

At this first step of the three-level hierarchical process our goal is to find the raw location of the markers, which can be treated optimal for the given position. The segmentation of the markers form the environment in a picture of a CCD camera is a picture processing problem. To avoid the use of complex, time-extensive algorithms we will support this segmentation by the use of spectral-selective markers and optics.

At the second step a laser beam with random scan capability is driven towards the marker. Due to the special optical construction of the marker a very large step in the reflected light's intensity can be detected when the beam targets the marker. The deflection angel of the beam is one of the information to be measured.

The laser beam is not only a positioning tool. By use of a high-speed photomultiplier a phase-modulated distance measurement head is installed. The deflection angle together with the sensor-marker distance makes good data-base for exact position calculation.

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Accurate trajectory tracing needs information about the true direction (and speed) of the robot movement. The acquisition speed must be very high in this case. At the third step our system follows the continuos change of the laser's deflection angle while it tracks the marker. This change is proportional with the robot movement for small distances.

OBSTACLE DETECTION AND DECISION MAKING FOR INTELLIGENT MOBILE ROBOT

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ABSTRACT

In this paper, a methodology for the navigation/steering of an autonomous robot for obstacle avoidance is described. The system is capable of performing "goto(x,y)" tasks with the avoidance of obstacles which where unknown to the system before hand.

The tasks can be defined related to a given two dimensional map of the platforms environment. Obstacles are detected with three optical (infra-red) switches. When an obstacle is detected a mechnism for detecting the relative distance of the two edges of the obstacle is triggered in order to let the robot make the decision in chosing the shortest way to avoid the obstacle.

The vehicle, has been designed with the specific aim of producing a low-cost intelligent/autonomous robot for material handling applications in (x,y) environment.

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Path Planning and Navigation of Overhead Traveling Crane with Three-Dimensional Transport based on a Diffusion Equation Strategy

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ABSTRACT : This paper presents a method for map-based path planning of overhead travelling crane with smooth collision-free paths by using a potential approach based on three-dimensional diffusion equations, and also a navigation strategy for the obtained path in order to realize the both of obstacle avoidance and swinging-suppression for transfer objects. In recent years, a lot of studies have been done on path planning based on the potential field in the mobile robots. However, no prior studies for overhead traveling crane path planning with three-dimensional transport has been addressed in spite of its importance. The particular significant points for crane path planning is that we must pay special attention to not only the obstacle avoidance of transfer objects and rope, but also the reduction of oscillation for transfer objects. First, collision-free paths of crane (transfer objects) between a start and a mission-dependent goal point are generated by off-line simulation of a diffusion process and evaluating the gradient of the computed concentration distribution functions. Some discussions are done on the selection of diffusion coefficients, mesh size and calculation repeated times of diffusion. Secondly, for the position and swinging-suppression control, command inputs shown in time-series(reference trajectory given by time-series) for the path obtained in potential fields must be given in order to implement feedback control systems. Generation of command inputs is decided under the consideration of the maximum velocity and maximum acceleration of crane. For command inputs, time-varying controller by a fixed-pole approach is applied for position control and swinging-suppression control. Especially, in the entrance of the excessive curved paths, a threshold technique is proposed such as command inputs is held for a certain time at the same position in order to compensate the delay of tracking which generates the collision. Finally, the usefulness of the proposed method is demonstrated by simulations and experiments. Application of the present approach to on-line path planning based on the unsteady diffusion process in a time-varying environments will be extended.

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Identification of Kinematic Chains Using Position and Length Measurements

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The accuracy of robotic systems can be improved by the proper identification of their kinematic parameters. This paper describes and compares several methods for the measurement of the position or the length of a link that is part of a closed kinematic chain formed by the measuring system and a robotic system.

A novel measuring device that uses cables to perform measurements is described. Measurements with one or three cables are compared to measurements with a standard double ball-bar device. A suggestion for a new double ball-bar type measuring device is made.

Several types of robots and kinematic chains are simulated and measured. Simulation results are included for an inverted spherical assembly robot and an eight-axis kinematic chain that describes a revolute common industrial robot and an industrial positioner.

In the numerical part the proper choice of modelling and the careful planing of measurements are significant for the convergence and the accuracy of the identification of the robot. Measurement accuracy is cardinal for the accuracy of the identified parameters. A non-linear least-squares method (Levenberg-Marquardt) has proved to be reliable even for large parameter deviations.

The algorithms for signature calibration have been implemented in C++ and in *Mathematica*.

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MICROCONTROLLER CONTROL of an ELECTRO-PNEUMATIC MANIPULATOR

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ABSTRACT: Materials transport and handling under harsh environments, leads to increased robots use. The paper designs, implements and tests a 3 arms electropneumatic, polar, microcontroller controlled manipulator of 3 dof, suitable for education and CNC tool changers. Its kinematics are presented. The system consists of the electro-pneumatic manipulator, the microcontroller and the interface drivers. The MC68HC11A1 presents high density and data transfer speed, low power level and noise immunity features, with on-chip peripherals; it is user programmable on various levels, types and quantity of memory. The manipulator software consists of drive, loading, delay, menu selection commands. Its hardware consists of a double acting pneumatic cylinder single acting cylinder, rotary valve (0-180°), electric valves, pump, single acting cylinder, adjusting, relief valves, orifices, throttles, etc. operating at 3 bar. The robot gripper is of the vacuum type with one suction cup.

At start-up and reset, to avoid unpredictable operation a start-up calibration certain sequence is performed at the edges of the working envelope. Most robots are programmed, led by the nose, or use for operators training, under primitive conditions and operating environmen. e.g. by moving two cans (or cards) with a hand around an axis of symmetry.

Open/closed loop, sequential/simultaneous, 3 axes (z, r, θ) and grip control tests are performed. A digitally operating CNC tool changer is simulated by steps such as move tool changer, rotate tool case, pick-up tool, lock tool, park old tool, etc. Robot's operational accuracy is investigated.

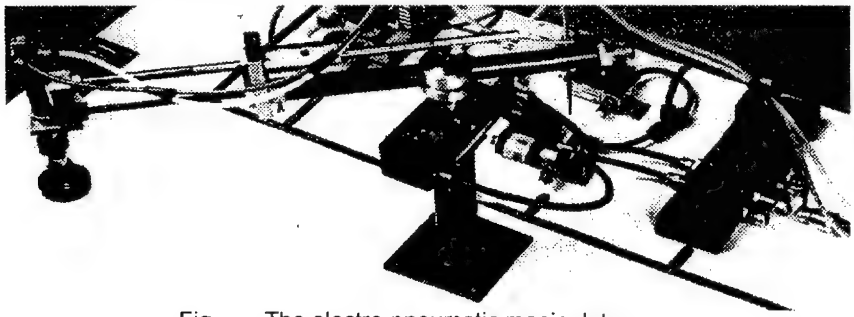

Fig. The electro-pneumatic manipulator

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AN OPTIMAL MODEL-FOLLOWING PROBLEM FOR LINEAR SYSTEMS

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In this paper a regulator synthesis problem for a linear system with a hybrid criterion – optimal and reference model – following is presented.

The problem is essentially a LQ optimization problem with finite time horizon. The criterion penalizes large variations of the command variable, state vector and imposes a desired dynamical behaviour. This dynamical behaviour is considered with respect to the state variables or output variables. The imposed value of the final time ensures a short transient time and, cosequently, a good proximity to the desired final value.

Previous results of the authors shows that it is avoided the use af a time-variant regulator, whicg is usualy used in the LQ problems with finite time horizon. The optimal command is obtained as

$u^*(t)= u_f(t) + u_c(t)$

where $u_f(t)$ is a feedback component and $u_c(t)$ is a corrective component.

The feedback component is identical with the one obtained in the similar LQ problems with finite time horizon.

The corrective component $u_c(t)$ containes other two components:

- the first one, $u'_c(t)$, which depends on the initial state and introduces the modifications that appears in the case of the finite time horizon,

-the second one, $u''_c(t)$, which depends on the desired values of the state vector, output and disturbances that may appear.

The solution obtained implies a large amount of off-line computing. The on-line computing, that must be performed in real-time, is sufficiently small and the algorithm can be inplemented on a fast CPU. The feedback component component $u_f(t)$ is calculated as to the usual state reaction and the corrective component calculus prezumes an iterative multiplication of a vector with a matrix each sampling moment.

The paper containes a short presentation of the method. There are derived the relations for the off-line computing of the regulator and the basic relations of the on-line calculus of the command variable. The vallidiy of the proposed regulator is tested by numerical simulation with the MATLAB package. The simulation results are given in the last section.

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Singular Value Properties of the Discrete-Time LQ Optimal Regulator

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ABSTRACT: In the present paper, a series of useful singular value properties for the deterministic state feedback discrete-time LQ optimal regulator, is established. These properties are obtained by extensively investigating the behavior:

a) of the minimum singular values of the regulator's return difference matrix, which is a fundamental transfer function interwoven with the study of the robustness properties of the regulator, and
b) of the singular values of the regulator's closed-loop transfer function compared to the behavior of the singular values of its open-loop transfer function.

Our investigation allows to suggest new lower bounds for the minimum singular value of the regulator's return difference matrix. On the basis of these bounds, we establish new guaranteed stability margins for such a type of LQ optimal regulators. These margins are, in many cases, sharper than the guaranteed stability margins, proposed in the literature. Furthermore, our investigation provides guaranteed stability margins in cases where known techniques fail. The proposed stability margins are obtained on the basis of a fundamental spectral factorization equality, called the Return Difference Equality, and are expressed directly in terms of the elementary cost and system matrices. Sufficient conditions to guarantee the required stability margins are presented and the connection between these margins and the selection of weighting matrices is investigated. Useful guidelines for choosing proper weighting matrices are presented.

On the other hand, it is known that the singular values of the closed-loop transfer function of the continuous-time LQ regulator are no greater than the singular values of the open-loop transfer function. Moreover, in the case of the output-weighted cost function, the singular values of the closed-loop transfer function of the continuous-time LQ regulator are no greater than the output-weighting parameter. However, as it is shown in the paper, for the discrete-time LQ regulator these two properties are not fulfilled. This is mainly due to the entanglement of the solution of the discrete Riccati equation to the aforementioned Return Difference Equality. In this respect, new results relating the singular values of the closed-loop and the open-loop transfer functions of the discrete-time LQ optimal regulator, are established in the paper. Illustrative examples clearly demonstrate the validity of our results.

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Response Optimization Of A Discrete-Time Bang Bang Optimal Control Problem

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ABSTRACT

A parameter optimization methodology is applied in solving a discrete-time, four integration variables optimal control problem of an initial-value ordinary differential equation, with Bolza objectives and mixed constraints. The objective function is equal to the second power of the Euclidean norm of the difference between the desired end position and the response vector at the corresponding time. Various versions of this problem have been discussed by a number of authors, who exclude its terminal inequality constraints. In opposition, the current approach takes into consideration all the inequality constraints, in the form of extended quadratic penalties.

The problem has a bang bang solution with eight switching times. This specified version is solved in the literature by using a discrete nonlinear programming formulation and by using a second-order method for problems with control bounds and bang-bang solutions.

The current optimization procedure focuses on the exact definition of the eight control variables corresponding to the times when the control signal is inverted. An alternative set of control variables is utilized by the optimizer instead of the initial set, in order to avoid the existence of additional constraints and equivalent global minima.

This optimization problem appears the following peculiarities : presence of many local minima, abrupt variations of the objective function, discontinuous first and second order derivatives and high computational cost. In order to face the above peculiarities an especially formed algorithm is proposed, based on a combination of the model of natural evolution and the deterministic Newton methodology, utilizing zeroth order information of the proposed analysis.

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ADAPTIVE NONLINEAR MODEL PREDICTIVE CONTROL USING AUTOREGRESSIVE-PLUS VOLTERRA MODELS

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ABSTRACT: In this paper an adaptive nonlinear Model Predictive Control scheme based on models identified from input-output data is proposed. We consider single-input single-output (SISO) nonlinear systems described by autoregressive-plus volterra models. The new indirect adaptive nonlinear controller is designed by combining the predictive controller with an indirect parameter estimation. Hence, the objective of this paper is to establish an attractive methodology that provides the user with practical procedures for structure and parameter estimation as well as for adaptive control of nonlinear processes based on models obtained from input-output data. The regressors and parameters are obtained using a stepwise model building algorithm. This approach employed statistical tests such as Akaike information criteria to determine significance of previously added regressors and to terminate structure selection. The Weighted Recursive Prediction Error Method (WRPEM) is used on-line for the estimation of the parameters. Once the structure of the autoregressive plus volterra model is selected, the data will be passed through the WRPEM algorithm several times until the convergence of the parameters. After the model is obtained the WRPEM is also used on-line to update the model parameters in the hope of capturing the variations in the plant.
One advantage of this model structure is that it can be identified from input-output information. Another advantage of this model structure is that it leads to a fourth-order nonlinear programm to be solved at each sampling time. This optimisation problem is more tractable than the nonlinear higher orders programms encountered in several other published nonlinear model predictive schemes. The third motivation of the present work is to investigate nonlinear adaptive predictive control algorithm based on autoregressive-plus volterra model. This adaptive scheme has been applied for the control of highly nonlinear dynamic process such as the Van De Vusse isothermal continuous stirred-tank reactor.
Simulation results was demonstrated that the performance of the autoregressive-plus volterra model based-controller was significantly better than that of a linear model predictive controller. This example also showned the ability of this approach to handle non-minimum-phase processes. An application of the proposed methodology to the control of an esterification batch reactor is under realization. Another direction under investigation is focused on the stability analysis and robustness characteristics of the proposed control scheme.

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PID AUTO-TUNING BY A COMPOSED STRUCTURE

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Abstract : It is proposed in this paper to reduce the excessive overshoot produced by the tuning of Ziegler-Nichols method and to obtain better rise time that tuning Aström method by using a structure called composed structure and by weighting the three actions of the PID controller by three factors F_i, F_p, F_d. These last factors are determined in function of the system parameters so as to guarantee a specified overshoot in closed-loop. The usual parameters K, T_i, T_d of the PID are fixed by the tuning of Ziegler-Nichols (Z-N) method, which provides a good rejection of the load disturbance. the auto-tuning of this method can be easily to obtain by using relay method [1],[9] for determination the Ziegler-Nichols frequency model parameters.

Key-Words : Automatic Control, Industrial Control, PID Structures.

A SENSITIVITY MEASURE FOR AN ELECTRONIC, PROPORTIONAL-DERIVATIVE CONTROLLER AND CALCULATING OPTIMUM PARAMETER TOLERANCES

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Over the last 15 years, control theory has developed several techniques for designing linear time-invariant control systems that are optimum and robust. It is shown that optimum and robust controllers, designed by these techniques can produce extremely fragile controllers, in the sense that vanishingly small deviations of the coefficients, due to the environmental effects, of the designed controller destabilize the closed-loop system. The fragility also shows up usually as extremely small gain and/or phase margins of the closed-loop system.

It is obvious that it would be unwise to place a controller that is fragile with respect to deviations of its coefficients due to the environmental effects in an actual control system without further precautions and analysis since deviations of controller coefficients cause the deviation of the output voltage of the controller.

Although reducing the deviations of the output voltage of a controller due to the environmental effects is very important in designing and in using such elements, this problem has not been examined and solved so far by sensitivity approach. In this study a method is proposed to overcome this problem by use of the sensitivity concept

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The proportional-derivative (PD) controllers are one of the most important control elements used in process control industry.. In this study, by the use of the sensitivities of the transfer function first an upper bound is given for the deviation of the output voltage of an electronic PD controller, then the optimum parameter tolerances are determined. These tolerances keep the relative error of the output of the PD controller due to parameter variations, in tolerance region. Then a sensitivity measure is defined to be used to improve the sensitivity performance of the PD controller and to compare various PD controllers with different set of design parameter values which realize the same transfer function.

Optimal Control of Time-Varying Dynamic Systems

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Design and implementation of controllers for time-varying dynamic systems is usually based on heuristic rules and on methods utilizing standard control design procedures. However one main problem of the controller design consists in the determination of its structure, including nonlinearities.

For the position control of a transported flexible material with irregular contour, common in textile industry, and also strongly varying dynamic characteristics during the transport, a novel controller design approach is proposed. The approach takes into consideration the on-off type and nonlinear dynamic of the actuator and also that a linear compensator fails to control the transported material.

Numerical simulations show the satisfactory performance of the proposed approach, which incorporates time varying control coefficients and a dead zone nonlinearity. The theoretical results are fully sustained by experiments, with real conditions including sensors and actuators, that prove also the non-sensitivity of the controller design in a real industrial environment.

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Route Selection in a Neuro-Fuzzy Vehicle Navigation System

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ABSTRACT :

The objective of this work is to develop an **optimum route selection** function in a modern vehicle navigation system. Dynamic route guidance system is gaining popularity nowadays. One functionality of such a system is route planning. After a driver has specified his destination, the system can work out many feasible routes. An advanced navigation would support the driver by ranking the possible routes. The first choice presented to the driver is obtained by an optimum route search function. In this paper, a neuro-fuzzy algorithm which is used for the design of such an optimum route selection function is presented.

The unique features of the algorithm are described as follows. First, a set of fuzzy rules which specify the personal preference of the driver is defined. Then, these fuzzy rules are implemented as a neural network. That is, we can obtain a special neural network, called **Fuzzy Neural Network** (FNN), which is equivalent to the original fuzzy system. The ranking of the feasible routes is carried out by the FNN. If the choice of the driver is not the first choice recommended by the system, it can store this result which will be used as a training data. Occasionally, the FNN can make use of the training data to adapt itself by a training process. The idea is that when a similar situation is presented to the route selection system in the future, the system can recall the previous choice of the driver. The training process involves an update of the interconnection weights of the FNN. Essentially, this can be translated to a change of shape of the membership functions of fuzzy rules. Hence, the route selection can be made adaptive to the choices of the driver.

The neuro-fuzzy algorithm for route selection has been developed and implemented in a novel digital map environment, called **Digital Hypermap**, at The University of Hong Kong. It is a kind of intelligent map, with information obtained dynamically online, and so the displayed map information should be completely current and update. The update is provided locally by the transport department, public transport companies, public works department, relevant hotels, restaurants and car parks etc. with the information placed on web pages in the Internet. The digital map is written in the **Java** language, and it has many special features such as dynamic links to the relevant web pages in the Internet.

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Neuro-Control for Multi-Variable Systems

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Abstract

Computational intelligence approaches like fuzzy theory, neural network, genetic algorithm, artificial life, etc. have been well-developed and applied to many real control problems in an efficient way. Recently, many neuro-control schemes have been proposed where neural networks can be trained to realize good controllers by learning an inverse model of the plant or a nonlinear emulator for the plant. Among many neural network learning methods, the error back-propagation(BP) method is the most widely used in a wide variety of applications. In control problems, there has been development on neuro-control for robots control problems. Although various intelligent control methods may be applied to this problem, PID control is the major approach. The main reason is that its structure is simple and PID controllers are robust with noise and parameter variations. As in real control problems the PID controller has been used as the major control methods, the operators select suitable PID gains from time to time based on their experience and knowledge about the plant dynamics. However, it is required to find a suitable PID gains automatically. To use the PID controller, we must tune the PID gains which have been determined by trial and error based on experience and knowledge of experts. In this paper, we propose a tuning method of the PID gains by using neural networks to control a single-input multi-output system and apply it to stabilization of the inverted pendulum.

Using the back-propagation method for learnig the neural network, various kinds of neuro-controllers could be trained in such a way that the desired plant output is attained as much as possible. The basic control scheme consists of the feedforward controller(FFC) and the feedback controller(FBC). The neuro-controller is used in FFC or FBC instead of a conventional controller. Three typical neuro-controllers are a series type, a parallel type, and a self-tuning type. In this paper, we consider the self-tuning type when FFC is neglected and the PID structure is adopted for FBC.

First, we will consider the self-tuning PID controller based on the neural networks when the system is described by single-input single output(SISO) variables.Then we consider a multi-variable PID controller by extending the previous one for the SISO case. In order to construct the self-tuning PID controller for multi-variable case, we introduce the neural network to tune the PID gains for two PID controllers. The tuning structure will be described through an example of stabilization of the inverted pendulum. The basic principle is to tune the total PID gains as the output of the neural networks. From the experiment we show the effectiveness of the proposed algorithm.

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An unsupervised fuzzy classification algorithm for the non elliptic classes

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ABSTRACT : Although they give high performance for the classes with elliptic shapes, the clustering methods don't provide a satisfactory answer to the problem of non elliptic classes. Some techniques, using the multiprototype approach, enable to adjust the algorithms to point clouds containing a class of parabolic shape. Several prototypes are created, then merged so that the membership level curves respect the shape of classes [5].
In the frame of our work dealing with industrial data classification and diagnosis with fuzzy pattern recognition, we are concerned with the problem of points clouds which contain classes of any shape.
In the first part of our article we show how the cloud of points is divided into a large number of subclasses by the fuzzy c-means algorithm [1]. Each subclass must belong to one real class only.
In the second part, we have developped a method which enables to merge the neighbouring subclasses. It's based on the construction of a proximity graph which uses the principle of ambiguity rejects [2, 3]. The research of connected components of this graph allows to know the subclasses to merge and then, to achieve the unsupervised classification.

Finally, we suggest to apply this method to several types of data in order to show the advantages and conditions required. We also show how it may serve as a learning foundation for unsupervised methods like k nearest neighbours or fuzzy pattern matching [5].

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A Synergistic Self-Organising System for Control Chart Pattern Recognition

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Control charts as used in Statistical Process Control can exhibit six principal types of patterns: Normal, Cyclic, Increasing Trend, Decreasing Trend, Upward Shift and Downward Shift [Pham and Oztemel, 1996; Pham and Chan, 1997]. Apart from Normal patterns, all the other patterns indicate abnormalities in the process that must be corrected. Accurate and speedy detection of such patterns is important to achieving tight control of the process and ensuring good product quality. Adaptive Resonance Theory (ART2) and the Kohonen Self-Organising Map are two unsupervised neural network paradigms suitable for pattern recognition applications. Though they offer many advantages, they also suffer from a number of shortcomings. Whilst ART2 overcomes the stability-and-plasticity dilemma, it is difficult to see clearly the effects that parameter adjustments have on the performance of the network. On the other hand, although the Kohonen Self-Organising Map is easy to use and able to retain the topological order of the training data space, it suffers from the stability-and-plasticity dilemma. Also, because of the neighbourhood updating scheme adopted, the training time required in a Kohonen map can be significant. In this paper, a synergistic system combining ART2 and the Kohonen Self-Organising Map for control chart pattern recognition is proposed. The architecture of the system is aimed at combining the advantages offered by the two separate paradigms and avoiding their respective shortcomings. Simulation results for the proposed synergistic systems is presented and discussed.

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Study of Intelligent Control of an Extension-Cableless Robotic Unicycle Based on the New Physical Measure for Mechanical Controllability on Examples of Different Unicycle's Mathematical Models

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ABSTRACT: The posture stability and driving control of a human riding-type unicycle have been realized. The robotic unicycle is considered as a biomechanical system using an internal world representation with a description of emotion, instinct and intuition mechanisms. We introduced intelligent control methods based on soft computing and confirmed that an intelligent control and biological instinct as well as intuition together with a fuzzy inference are very important for emulating human behaviors or actions. For the fitness function of the GA, a new physical measure as the minimum entropy production for a description of the intelligent behavior in a biological model is introduced. Furthermore a new unicycle model with extension-cableless design which can more really emulate human riding type unicycle robot is developed. Experimental and simulation results with use "simple" and "complicated" mathematical models of the robot for the comparative analysis are here described.

Computer simulation using dynamic two types equations of motion of the developed unicycle robot has been carried out according to the proposed control scheme. And the experiments have been conducted with the proposed fuzzy gain schedule PD-control method. Experimental results, show that both robot's longitudinal and lateral posture can be stabilized successfully. Thus, the proposed fuzzy gain schedule PD-control method provides one of the reasonable approaches to handle such a nonlinear problem existing in the unicycle robot system.

In this paper the thermodynamic approach for investigation of an optimal control process and artificial life of mobile robots is used. A new physical measure, the *minimum entropy production* for the description of the intelligent dynamic behavior and thermodynamic stability condition of a biomechanical model with an AI control system for the robotic unicycle is introduced. This measure is used as a fitness function in a GA for the computer simulation of the intuition mechanism as a global searching measure for the decision-making process about the optimal control of a global stability on the robotic unicycle throughout the full space of possible solutions.

From the results obtained in this study by the fuzzy simulation and soft computing, based on GA and FNN, it is obvious that the intelligent behaviors controllability and postural stability of the robot is largely improved by two fuzzy gain schedule PD-controllers in comparison with those controlled only by a conventional PD and a fuzzy gain schedule PD-controller. Furthermore an important result is that the minimum

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entropy production gives a quantitative measure concerning to the controllability as well as the qualitative explanations. We provide a *new benchmark* for the controllability of unstable nonlinear nonholonomic dynamic systems by means of intelligent tools based on a new physical concept of robust control, the minimum entropy production in control systems and in control object motion in general. Now we study the application of this control method to the new extension-cableless unicycle model (Fig. 1).

Key Words: Soft Computing Algorithms, Robotic Unicycle, Robust Intelligent Control, Posture Stability, Controllability, Fuzzy Control .

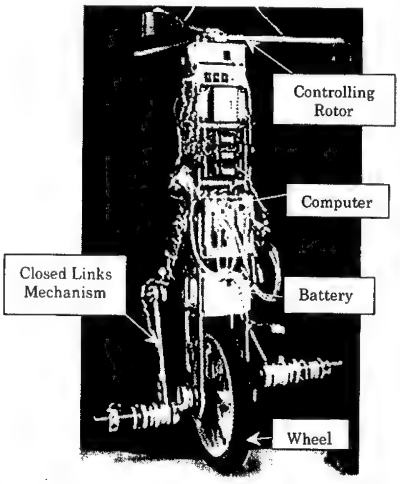

Fig. 1. Photo of extension-cableless unicycle robot.

Performance of RBF neural controller for transient stability enhancement of power system

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ABSTRACT: Parameters in electrical power system (PS) are changed with time, slowly due to environmental effects or rapidly due to faults. Thus it is necessary to update the control law with system changes.

Design of adaptive controllers to improve the performance of power system has been topic of research for a long time and is actually at present. Neural networks (NN) are suitable choice for the control of complex nonlinear plants since the conventional control methods show limitations in performance. Due to some desirable features such as local adjustment of the weights and mathematical tractability, radial basis function networks (RBF) have recently attracted considerable attention. When the basis function are fixed, the outputs of networks are linear in the coefficients (the network weights). Then the results of the theory of linear systems can be applied to the weights adaptation and RBF net integration in control design.

One of the promising applications of NN in PS is in the area of power stabilization. Neural network based power system stabilizers (PSS) are shown very effective in damping out the PS lower frequency oscillations and experimentally are shown to have much better performance over a conventional PSS. Another important applications of NN controller is for transient stability enhancement. This is a subject of this paper.

To enhance first swing stability a RBF neural network fastvalving controller is proposed. The solution approach is based on a recent fuzzy fastvalving control scheme (Babu et al., 1997). But the fuzzy logic control suffers from the disadvantage of having to obtain fuzzy rules by trial and error and the requirement of good knowledge of the system behavior. The learning capabilities of NN are used to overcome this problems. RBF neural structure is selected as closely related with fuzzy logic approach.

The objective of the fastvalving is to modulate the mechanical power input by suitable changing of the valve position. Thus the output of the RBF NN controller is the change in valve position. The inputs are the speed error and the variation in the electric power.

The design steps of proposed RBF neural controller are explained. Disturbances in PS are used for training the NN controller. The performance of the RBF neural controller is simulated in a single machine to an infinitive bus power system.

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Estimation of state variable in power system combining theoretical knowledge with RBF neural network

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ABSTRACT: Radial Basis Function (RBF) neural networks offer an attractive form for using in control applications. This type of neural networks possesses local adjustment of their weights and mathematical tractability. Taking into consideration the features of RBF-nets it is interesting to investigate the applicability of this neural structure for real-time modeling and estimation of state variables in such complex nonlinear systems as power systems.

A simplified dynamic model of power system is considered, namely a single generator connected through two parallel transmission lines to a large network approximated by an infinite bus. The power angle $\delta(t)$ should be available for designing an appropriate feedback law for the system. In the paper it is proposed to evaluate $\delta(t)$ using neural network approach combined with existing knowledge about the power system. First, a dynamic simulation model of the system was developed by using mathematical equations that describe the behavior of the power system. Then on a base of this model a neural network was trained as an observer to the system. The inputs of the neural network x are δ values obtained from a dynamic simulation model. The outputs y are ω values. There is function $\omega=f(\delta)$, and the RBF network is constructed so as to produce a fitting surface to the function f. The phase plot $\omega=f(\delta)$ may be interpreted as the generator of the observed data. The locations on the phase plot produce the $(x,y)=(\delta,\omega)$ input/output pairs. Under constrained disturbances the generalizing abilities of neural network allow to reconstruct $\delta(t)$ from on-line measurements of $\omega(t)$.

The RBF network abilities to model and estimate $\delta(t)$ were tested by digital simulations. The influence of parameter variations and measurement noise were explored. For noisy data it is need more neurons in RBF network structure to model the system dynamic and to estimate the state variable.

The simulation results indicate that a neural estimator composed of radial basis activation functions is capable to provide very small estimation error.

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Condition monitoring of Hot Rolling Mill pre-set using Neural Networks and Statistical Techniques

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Abstract

The rolling process is very complex and it is not easy to model. There are hundreds of intermediate conditions impossible to reproduce because most of them are unknown or un-measurable. Statistical models are a first approximation to the introduction of historic data, but with some limitations: in general models are divided into several groups which tables are actualised simultaneously, so the solutions space is considered discontinuous. Also traditional models does not consider non-linearity in the relations between data or, at least, high degrees of non-linearity.

In this work we present partially a system to determine the final quality of the strip from the process variables. This objective was firstly tested in previous steps of the rolling and finally here it is applied to the determination of the width and thickness of the RM, the influence of the set-up forces and the generation of the best adapted alternative set-up values.The system developed provides the process technicians with a tool with the following features:

- Monitoring of the strip set-up.
- Generation of alternative set-ups considerate more accurate.
- Generation of the most probable value of error and its graphical representation in the errors space.

The objective is faced using a combination of techniques in the field of NN. Its formulation is simple (mathematically) and the speed of execution is perfectly valid for on-line work. Anyway neural networks are not the solution for any problem. They present some limitations, especially for extrapolation and when there are not enough historic points available. So we have used a mixed system which combines several different techniques to provide the maximum information about the process, mainly non-linear projectors and neural networks.

A combination of techniques is applied to a Hot Strip Mill to produce an enhancement in the dimensional accuracy outside the stands. The model is structured in two levels: a first approach based in classification and projection to produce alternative force set-up and a second level to produce a numerical value for the thickness and width variables. A new system is created on the projection to monitor the condition of the process in a visual form.

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MULTIMEDIA DSP EDUCATION

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ABSTRACT

In this paper, we present an object-oriented internet-based online laboratory for DSP and multimedia signal processing experiments. The laboratory has been developed as a series of Java applets that support a user-friendly simulation environment called JAVA-DSP (J-DSP). J-DSP allows users to construct and simulate different DSP systems by using a library of objects associated with a variety of signal processing operations. The library includes 1-D and 2-D signal generation, 1-D and 2-D IIR and FIR filtering, adaptive filtering, and interactive modules for speech and image processing. Moreover, J-DSP contains objects for parametric and non-parametric spectral estimation and signal modeling. J-DSP is currently being used at Arizona State University to support an online multimedia laboratory for senior and first-year graduate level courses in DSP and in Speech and Image Processing. J-DSP can be accessed at http://www.eas.asu.edu/~eee407/

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Colour Image Segmentation for Multimedia Applications

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I. ABSTRACT

Multimedia visual data is becoming increasingly important in many scientific and commercial arenas with the advent of applications, such as multimedia databases, colour image and video transmission over the Internet, digital broadcasting, interactive TV, video-on-demand, computer-based training, distance education, video-conferencing and tele-medicine, and with the development of the hardware and communications infrastructure to support visual applications. Visual information, such as visual streams is difficult to handle both in terms of its size and the scarcity of tools available for navigation and retrieval. To meet the challenging tasks in multimedia applications there is a need for new sophisticated model-based schemes for a high level description of video data. At the front end of these model-based multimedia image and video algorithms is a need for quick and accurate, application independent, image and video segmentation techniques. Image segmentation refers to partitioning an image into different regions that are homogeneous with respect to some image feature. An efficient colour image and video segmentation technique that can be used in the low-level analysis of multimedia-based still and video images will be developed. It will incorporate many features of the image including colour, texture, and the motion feature of video. The proposed scheme will help in the tracking of objects in video for the purpose of coding and compression. It will be used in video shot detection and video indexing. The proposed scheme will incorporate region-based, egde-based, pixel-based, and motion-based techniques of colour image segmentation.

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Estimation of 3D Motion and Structure of Human Faces

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Abstract

Information regarding the three dimensional shape and motion of human faces is frequently required in various applications such as computer vision, robotics, video coding, 3D modeling for animation, security systems, enhanced man-machine interfacing, etc. Depending on the application the extraction of either 3D shape parameters or 3D motion is tackled by mechanical sensors, 3D scanners or stereo cameras.

In this work we present a novel procedure that simultaneously estimates the shape and motion of a human face on the basis of a sequence of three arbitrary views of the head.

The first step of the presented algorithm is to obtain 2D motion estimates of the most characteristic face elements (iris and edges of the eyes, nose, lips edges, etc.). The second step uses these 2D motion vector estimates and based on appropriate modelling of 3D translation/rotation of rigid objects yields estimates of the corresponding 3x3 rotation matrices and the axes of rotation as well as estimates of face's translation. The third step computes the 3D shape information (depth and relative position) of the initial characteristic points. Computation is based on the 2D motion vectors obtained at the first step and the rotation/translation estimates of the second step.

Variants of robust 2D motion vector estimation algorithms that exploit the previously estimated motion parameters of the face are also proposed. The estimates that these algorithm yield for the remaining - non characteristic - points of the face are next used for the accurate extraction of 3D position information of the latter.

Simulated experiments illustrating the performance of the proposed algorithms are presented.

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A MULTICAMERA ACTIVE 3D RECOSTRUCTION APPROACH

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ABSTRACT

In this paper we present a methodology for creating three dimensional models of objects. First we merge techniques and algorithms used in stereo vision together with methods used in active laser range scanners and finally enhance the created model by a neural network.

In stereoscopy two different views of the object are processed and features extracted from the images are matched against each other. Based on the disparity of the corresponding features depth is estimated. Several problems occur during feature extraction and matching resulting in many cases in an inaccurate and ill-defined object model. On the other hand in active laser scanning systems depth is computed by triangulation, that is by measuring the disparity of the trace of the laser beam on the object. Laser triangulation requires very precise machining of the mechanical structure which oscillates and moves around the object. An additional problem is that shiny parts of the object reflect the beam and then the measured position is incorrect.

In our approach the object is surveyed by several cameras in order that all sides of it are visible by at least two cameras. Then a laser beam scans the object and measurements are taken by processing the images of the suitable cameras. We do not require any knowledge of the position of the laser beam. All calculations are made by processing the images after having calibrated the cameras and compensated any errors and distortions of the lens and the sensor. Processing involves tracing of the laser beam and performing stereoscopic matching based on the detected beam trace. Object reconstruction follows the processing step. During reconstruction the object is also processed by an artificial neural network which determines areas that require higher spatial sampling frequency. Appropriate training of the network using surface characteristics is described in the paper. Then the object is scanned again in the areas derived by the network. The proposed methodology has the following advantages: - provides high accuracy by fusing several sensor data and by super sampling, - does not require position measurements of moving parts, - any defects and distortions are compensated accurately by software calibration, - proper placement of the cameras provides a continuous coverage of the object.

Results taken from real experiments on 3-D ship structure model generation are used to illustrate the proposed technique.

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A Java-based Image Processing Package

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I. ABSTRACT

The recent Internet phenomenon has impacted all walks of life. E-Commerce, Networking, and the World-Wide-Web have become household words. Programming, which is the heart of all computing, has not been invulnerable to the Internet boom, and has changed for the better. *Java* as an entity has led to the coining of the name *Applet*, and more importantly spearheaded the architecture-independent programming revolution. The whole idea of not having a single version of code for all computing platforms is extremely important because it saves both time during the development stage, In addition, *Java*-based code results in a savings of disk space since binary files that are exclusive to individual machine architectures are eliminated. On top of all the practical advantages involved with its use, *Java* is an object-oriented, multi-threaded, and above all, easy to learn programming language. Characteristics such as the latter, make programming in *Java* extremely conducive to learning, and it is for this reason that it is important for the existence of software packages that can encourage the development of computational algorithms in all fields. *IMAGEnius* is just such a software package aimed at image processing. Written exclusively in *Java*, at the Digital Signal and Image Processing Lab at the University of Toronto, *IMAGEnius* is an architecture-independent program which is unique due to the fact that it is completely open for anyone wishing to incorporate new or improved algorithms to existing program code. Furthermore, *IMAGEnius* currently includes many state-of-the-art image processing algorithms, as well as conventional techniques for image manipulation, filtering, and analysis. This software package has been slated for incorporation into the graduate Digital Image Processing course at the University of Toronto as a learning aid for students. Since *IMAGEnius* was developed to act as a testbed for new image processing algorithms, it has the ability to allow new users to explore and experiment with the implementation of filters, and routines, and thus provide immediate hands-on experience to theory. As an ever-growing program, *IMAGEnius* provides a simple, yet powerful tool for the implementation and comparison of image processing algorithms.

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SIRES IEEE CSS GREEK CHAPTER MobiNet MOBINET

A Colour Co-ordinate Normaliser Chip

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Colour adds a new dimension in machine vision and aids in building more robust and reliable systems. Limitations of possible applications of colour machine vision have been associated with high cost and low processing speed of the added information. It is one of the defining attributes of objects and it is usually represented by means of a suitable colour space that consists of a co-ordinate system equipped with a distance measure. RGB is the most frequently used colour space. However, in the RGB colour space colour features are heavily correlated and, thus, the metrics make impossible to evaluate the similarity of two colours from their distance in the colour space. Also, the raw R, G and B data are sensitive to light intensity variations. rgb or colour fractions, or normalised colour co-ordinates, or chromaticity colour space are defined as follows: r=R/(R+G+B), g=G/(R+G+B) and b=1-r-g. In this colour space effects such as shadows and shading variation may be reduced or eliminated, and, thus leading to simplified image segmentation. Experimental results will be presented.

This paper presents the design and VLSI implementation of a new ASIC which performs real-time conversion of the raw RGB data, obtained from a colour sensor, into the rgb normalised colour co-ordinates. The high speed of operation is achieved by pipelining the data in a vector fashion. Eight-bit colour images have been used, since this resolution is adequate for encoding the composite video signal without noticeable degradation. The inputs to the circuit are RGB digital data obtained from a colour sensor and digitised through three flash ADCs. To describe the circuitry of the normaliser, only one channel (The R channel) will be considered as the other two will be symmetrical. The high speed of operation is was achieved by pipelining the data in vector fashion. Signal processing at video rates is a demanding task. The basic function of the normaliser can be described by the function r=R/(R+G+B). The implementation of this function can be split into two sections (i) calculate the intensity, (ii) calculate the normalised value r. The first section can be implemented for an n-bit system using two adders (one n-bit and one (n+1)-bit). The second section is more difficult to realise efficiently due to operation of division. In this case, the divider is constructed from a multiplier (one multiplier has been used for all three co-ordinates) whose inputs are R and 1/I. To generate 1/I a look-up table is used to hold all the pattern pairs for all combinations of 1/I (resolution issues will be addressed). The design has been implemented using the CADENCE VLSI CAD tool. The die size dimensions for the core of the chip are 1.86 mm x 1.77 mm = 3.29 mm^2, for a DLM, 0.7 μm, N-well, CMOS technology.

The ASIC is intended to be used in real-time pattern recognition applications, such as robotics, military systems, food, printing, pharmaceutical and agricultural industries.

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On the Solution of One-Variable and Two-Variable Lyapunov's Equation via Fast Fourier Transform (FFT)

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Abstract:- In this paper, a fast algorithm for the solution of one-variable and two-variable Lyapunov's Equation is presented. The algorithm is based on the use of the FFT (Fast Fourier Transform). The simplicity and efficiency of the method are illustrated by a numerical example.

Fast Fourier Transform (FFT), [1], has been applied in many problems in systems theory in order to facilitate or at least to speed up the relevant algebraic manipulation.

In [2], the FFT is used in order to determine the characteristic polynomial of a rectangular matrix and in [3] the same technique is used for the calculation of a Determinant Polynomial. The extension of this technique in 2-D systems is given in [4]. The use of FFT for arbitrary transformations of one-variable polynomials and rational functions is known [5].

In this paper, we consider the one-variable Lyapunov Equation: $A_1(s).XB_1(s)+...+A_n(s).XB_n(s)=C(s)$ as well as the two-variable Lyapunov Equation: $A_1(s_1,s_2).XB_1(s_1,s_2)+...+A_n(s_1,s_2).XB_n(s_1,s_2)=C(s_1,s_2)$. It is not difficult, based on the solution of the simple Lyapunov Equation: $A_1.XB_1+...+A_n.XB_n=C$, to formulate algorithms for the solution of one- and two-variable Lyapunov Equation via FFT.
In Section II, the algorithm is stated for the one-variable Lyapunov Equation whereas in Section III, the algorithm is described in the case of the two-variable Lyapunov Equation. Finally one can find some concluding remarks.

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An Interactive Contraint Solver for Computer Aided Design

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A new generation of CAD systems has become available in which geometric and dimensional *constraints* can be defined to determine properties of mechanical parts. The new design concept, often called *constraint-based design* or *design by features*, offers users the capability of easily defining and modifying a design, but introduces the problem of solving complicated, not always well defined, constraint problems. We have developed an innovative interactive constraint solver for handling geometric configurations faced in such CAD/CAM systems.

The constraint solving system is built around a graph-constructive constraint solving method capable of efficiently treating *well-determined*, *over-determined* and *under-determined* configurations. The method works in two phases, in the *analysis phase* the constraint graph is analyzed and a sequence of elementary construction steps is derived, and then in the *construction phase* the sequence of construction steps is actually carried out. The graph algorithms involved in analyzing the constraint configuration have a quadratic worst case time complexity and an almost linear time complexity in average.

To cope with the root selection problem, an interactive tool is provided for navigating the constraint solver to the intended solution. The user is presented with the construction sequence and is given the capability of modifying the relative positioning of the objects involved, thus affecting stepwise the overall solution selection.

Consistent over-determined sub-configurations are detected, relaxed and solved appropriately. Under-determined subsystems are detected, isolated and subsequently presented to the user annotated with all possible constraint addition choices for interactive editing.

Minimal systems of geometric constraints that are not solvable by the core constructive constraint solving method are detected and handled by a numerical method. The convergence of this method is interactively driven by the user to the intended solution with a satisfactory success rate.

To realize the constraint solving method we have developed a prototype on a SUN Ultra–3000 Enterprise machine running Solaris 2.5.1. The graphical user interface was built in Java AWT, the core method was implemented in SETL (SET Language), and the numerical method was programmed in MATLAB.

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GPS Position Estimation Algorithm Using Stochastic Modeling

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ABSTRACT: The derivation of direct, or closed-form solutions of the trilateration equations used to obtain the position fix in the GPS receiver is undertaken. This paper is concerned with the development of a new closed-form position and clock bias estimation algorithm that works in the presence of pseudorange measurement noise and for an arbitrary number of satellites n, where $n \geq 4$. Thus, the mathematical derivation of a general closed-form solution algorithm to the GPS pseudorange equations using stochastic modeling is presented. The closed-form algorithm provides an estimate of the GPS solution, viz., user position and user clock bias, as well as the estimation error covariance. The experimental results based on 5000 Monte Carlo runs are produced through realistic simulations of typical NAVSTAR GPS low noise, near-earth navigation scenarios and of ground-based pseudolite planar array scenarios. The results are compared to the baseline results from the conventional Iterative Least Squares (ILS) algorithm, which is currently used in GPS. The closed-form algorithm is extremely sensitive to noise in typical NAVSTAR GPS scenarios, making it unsuitable for stand-alone use; however, it performs very well at estimating horizontal position parameters in ground-based pseudolite planar array scenarios where the ILS algorithm breaks down due to poor geometry. For typical near-earth scenarios, the use of an additional nonlinear measurement in a supplementary algorithm is required to enhance the solution. Thus, the derivation of two supplementary algorithms is presented; the first is based on a maximum likelihood approach and the second uses a Kalman-like update step. The maximum likelihood algorithm based on iterative optimization is capable of producing solutions equivalent to those of the ILS algorithm; however, it cannot predict its estimation error covariance. The performance of the Kalman update algorithm is marginally degraded, most notably in its user clock bias estimation errors, but it is capable of predicting its estimation error covariance. The latter is dependent on how well the closed-form algorithm estimates the pseudorange measurement noise strength, which is a function of satellite availability. In conclusion, the performance of the direct algorithm is comparable to that of the ILS algorithm, the main advantages introduced being: 1) The capability to predict estimation error covariance, and 2) The potential for computational efficiency due to the closed-form nature of the solution.

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Natural Language Interface to an Agent

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ABSTRACT: The present paper presents the design and implementation of a natural language interface for a motion command understanding system. The system accepts Greek and English as the natural language of communication of the user with the system for the execution of motion commands. The system is applied to the communication between a user and an artificial agent, which moves in a virtual environment and accepts commands and knowledge about the objects and the actions possible in this environment. It is supposed that the agent can move around in a room for executing the user's motion commands. These commands may refer directly or indirectly to the movement of specific objects or the change of their state. The agent knows the names of these objects and their position in the room displayed on the screen. The agent also knows how to execute some basic commands. When the user submits a command, the agent, in order to satisfy the constraints of the verb's meaning, may ask for new information and knowledge about objects and verbs, which may be used for the execution of similar commands in the future. The commands express three kinds of actions. The first kind of action is change of position e.g. the movement of an object, the second kind is change of state e.g. the opening or closing of some objects and the third kind is the change of a relation between objects e.g. to placement of an object on top or inside another object. Motion may be specified by a verb either directly or indirectly. Indirect specification of motion is expressed in terms of a goal involving physical relationship among objects. Such commands require that a physical object be moved with a goal to establish a physical relationship with another object. Performance of such an instruction requires that the goal of establishing a physical relationship drives the motion of the first object. For verbs such as "put" that specify motion in terms of a geometric goal, properties of the objects that participate in the action are of crucial importance. Indirect specification of motion in terms of a force uses verbs such as "push" and "pull". Objects affected by motion commands may be also specified either directly or indirectly. Direct specification is based on names of objects known to the system. Indirect specifications can be accomplished using complex noun phrases. The lexicon of the system is created automatically using a machine readable dictionary while learning the correct interpretation of commands with more than one meaning is accomplished using machine learning by supervision based on visual feedback. The system has the ability to learn from its user to understand and execute correctly motion commands that go beyond its initial capabilities as shown by appropriate examples.

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Determining the Visual Interpretation of Actions in Interactive Stories

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ABSTRACT

Recent advances in AI and Web-based multimedia technologies encourage the development of interactive entertainment forms, such as interactive stories, that seek to create engaging stories that are meaningfully interactive. However, these systems can become successful only if they manage to deliver engaging stories. Consequently, research in this area must develop effective visual interpretation techniques that communicate the informational, aesthetic and dramatic aspects of each story equally well. These techniques should exploit the ability of the computer to dynamically combine different media and create interesting dramatization effects during story delivery.

We describe a novel method for determining parts of the visual interpretation of actions in interactive plots. The method accepts as input a story plot consisting of a tree of possible character actions, their motivations and outcomes. It also accepts as input a 2-D layout of the 3-D space in which the story will play out and a list of possible behaviors for each of the objects in the description. The method uses this input to compose 3-D renditions for each story action by assigning automatically behaviors to the objects in the scene based on performance-related descriptions of story actions. These renditions are enriched automaticalyywith appropriate multimedia effects that seek to emphasize their dramatic nature. The effectiveness of this method is currently being tested in extensive user trials of an interactive adventure story that has been deployed on the Web. Possible uses for this research include the development of intelligent tools for the design or real-time direction of interactive stories or games.

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A Smart Load Balance Scheme for an Automatic Arbitrage Detection System

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Models that detect arbitrage opportunities in capital markets require real-time computing intensive systems that exhibit fast system throughput. A key characteristic of such models is that the complexity and consequently the execution time varies from a few milliseconds to several minutes. The response time of such a system is critical since arbitrage opportunities rarely last for more than a few minutes. An HPCN system is an ideal platform for implementing applications that exhibit the above characteristics. Yet, these requirements cannot be easily met unless special consideration is given to the way jobs (arbitrage models) are scheduled and dispatched in the distributed environment where the application is executed. Thus, the need for a self-adapted load balancing mechanism is arising. Such a load balance scheme must be scalable to accommodate for increased workload requirements by exploiting the most of the available resources. Since the application is executed on a multi-user environment consisting of heterogeneous computing elements, (i.e. personal computers, workstations) with varying availability of processing resources, the load balance scheme must ensure the portability and the interoperability of the application

In this paper we present a smart and efficient Dynamic Load Balancing (DLB) scheme capable of adapting to the workload of the system. This DLB scheme optimizes the application response time by converting the inherent coarse grain parallelism into a fine grain, while maintaining maximum utilization of the communication network. The system uses job handling policies guided by the computation load, as well as by the statistical analysis of the job execution times. The statistical analysis is performed on-line during the life of the application (learning procedure). The DLB dynamically decides if a number of jobs must be packed and assigned to a processing unit (achieving this way the maximum CPU usage) or if each single job will processed separately (minimizing this way the wait time and achieving the optimum communication network usage).

The above load balance scheme is implemented as a part of an arbitrage detection system that provides advice to traders. This system accepts financial information from Reuters TriArch network, computes synthetic assets, and publishes information regarding arbitrage violation back into the same network. The execution platform is comprised of several low cost personal computers and workstations of various architectures interconnected via a high-speed network that form a distributed system. The presented DLB scheme is implemented as an object oriented application using the MPI(Message Passing Interface) parallel programming platform. Therefore it is portable and can be used as stand alone load balancing module.

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A Case Study in Specifying the Denotational Semantics of C

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Abstract

The C programming language represents a strong and indisputable status quo in the current software industry. Its semantics is informally defined in the international standard ISO/IEC 9899:1990, using natural language. This causes a number of ambiguities and problems of interpretation about the intended semantics of the language which may become hazardous in the case of programming critical systems' software, an application area for which C is widely used. The need for a formal definition of the semantics of C has become apparent.

In this paper we present a brief summary of our research in specifying a complete and accurate formal semantics of the ANSI C programming language. Since a thorough technical treatment of the subject would be inevitably too long, the paper is written as a case study describing the methodology that has been followed and briefly outlining the semantic description. It is demonstrated that a programming language as useful in practice and as inherently complicated as C can nonetheless be defined formally. The proposed semantics can be used as a precise, abstract and implementation-independent standard for ANSI C. Moreover, can be used as a basis for the formal reasoning about C programs and a valuable theoretical tool in the software development process.

We follow the denotational approach and use monads and monad transformers, in order to improve the modularity and elegance of the semantics. The specification is divided in three distinct phases: static, typing and dynamic semantics. Apart from the main contribution of this research, which is the proposed semantics itself, interesting results have been achieved in our attempt to accurately model complex characteristics of C, such as unspecified order of evaluation and sequence points, using monadic notation.

An implementation of an abstract interpreter for C programs based on the proposed semantics has also been developed, using Haskell as the implementation language. The implementation has been used to evaluate the accuracy and completeness of the proposed semantics. Although this process is still under way, the results so far have been entirely satisfactory.

Keywords: ANSI C programming language, ISO/IEC 9899:1990 standard, formal definition, denotational semantics, monads, monad transformers.

Using Forward Temporal Planning for the Production of Interactive Tutoring Dialogues

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Generating and monitoring a tutoring dialogue aiming to guide users to solve a problem is a task that requires a method to diagnose whether user actions are consistent with the problem's solution or not [1]. This requires that the tutoring system can analyse the user's final goal (solving the problem) into a sequence of lower-level goals [2] and define what the user's actions should be in order to achieve these goals.

Intelligent Planning techniques can considerably help in the design process of such a dialogue system by providing a method to decide wheter a user action logically depends on previous ones and that the course the user follows will finally lead to the main goal. Traditionally, planning systems employ backward-chaining search strategies to solve a variety of practical problems. However, in a group of problems, such as equation solving, it seems that a forward-chaining strategy needs to be applied [3], as the set of world states that preceeds the current one is infinitely non-deterministic.

We propose a temporal forward planning system which is based on the TRLi temporal reasoning system [4] for the representation and reasoning of temporal information. The action representation schema that we adopt has been described in the backward-chaining version called TRL-Planner [5], but is appropriately extended to cover the needs of interactive tutoring dialogues.

Equation solving was selected as a case study. The forward planner generates the sequence of steps the student follows when an answer is given. This plan is used in order to diagnose the student's misconceptions and misbeliefs, so as to provide guidance and clarify the various concepts, as well as the solution process itself.

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The role of planning in scheduling Patient Tests in Hospital Laboratories

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Scheduling patient tests in hospital laboratories is an interesting real-world problem where AI planning technology can be applied. Doctors prescribe tests to be performed in order to assist the diagnosis. Hospital laboratories which perform tests, must cooperate in order to maximize the utilization of their equipment and minimize the patient waiting time. The actual timing of the tests prescribed for a particular patient, depends on several factors that require both planning and scheduling technology to be used.

Till now, approaches that cope with this problem use pure scheduling techniques. Between them, there are centralized scheduling approaches that consider scheduling tests in a single laboratory and distributed scheduling approaches based on equipment-wise distribution that assign different schedulers to different laboratories. Towards this direction, we have proposed a prototype scheduling system which introduces a patient-wise dynamic distributed scheduling approach. Further, we have also made a first attempt to integrate planning and scheduling techniques in a planning/scheduling prototype. In that version, a new plan needs to be created for every request, even though such requests are frequently repeated. This means that in case of a major destructive event, all previously scheduled requests have to be planned and scheduled from scratch.

In the present paper a more thorough approach of the dynamic distributed planning/scheduling paradigm is given, which supports incremental scheduling. We first examine the need to incorporate AI planning technology within the problem of scheduling patient tests in hospital laboratories and suggest appropriate techniques that should be applied in order to represent and reason in such a domain. Then we describe an enhanced version of a planning system, called TRL-Planner that fits the requirements for representing and reasoning patient tests in hospital laboratories. TRL-Planner is built upon the TRLi temporal reasoning system and is able to handle both temporal and resource constraints. TRL-Planner is used a) off-line to generate plans to be stored at a plan repository and b) at the time a new unplanned request is arrived to give a set of alternative plans and also update plan repository. After selecting a plan, the time frames available are considered in order to produce a viable schedule. Incremental scheduling is supported in case that resource allocations have changed during the scheduling process or unexpected events kicked out some resources. Then the schedule is adapted to the new situation without rejecting those parts that are not influenced by the change.

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Critical judgements on feasible emergency manoeuvres : a comparative study between test track and driving simulator

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This research is part of a validation program of the fixed base INRETS simulator, which has been under progress for 2 years. The work presented here is a replicate of an experiment carried out on a test track by Malaterre in 1987. The aim of this research was to determine if subjects (12 experienced drivers) placed in a simulated emergency situation (the subjects never actually performed the manoeuvre), were able to perceive that above a certain speed swerving remained possible nearer to the obstacle than braking. This is a complex judgement. It relies on a good perception of Time to Collision but also on a good awareness of the dynamic properties of the driven vehicle. We used a similar procedure on the simulator, but with two visual field widths (25 and 64°).

The subjects who drove the simulator were invited to indicate by pressing a switch the last moment beyond which the manoeuvre would not be possible. The obstacle was simulated by plastic cones and the subjects were instructed to drive between them after they had pressed the switch, and then to keep their speed unchanged. The data were converted into theoretical longitudinal acceleration for both manoeuvres, in order to make the comparison possible. They were collected for speeds varying from 40 to 120 km/h.

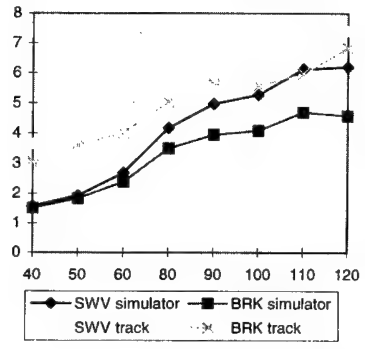

Figure 1 : theoretical longitudinal acceleration ($\gamma = S/2 \times TC$; with S for speed and TC for Time to Collision) according to situation (simulator and test track), manoeuvre (swerving and braking), and speed (km/h).

The results exhibit similar tendencies on simulator and test track. In both cases swerving was estimated possible closer to the obstacle than braking for comparable speeds, which fits with the physical model. On the other hand, whatever the manoeuvre, accelerations corresponding to drivers' estimates are significantly lower on the simulator. This result reveals a tendency to adopt larger safety margins on simulators, maybe because drivers are not so confident in their estimates in this situation than in actual driving. Women perceive the advantages of swerving as well as men, but initiate both manoeuvres farther from the obstacle. This last point is consistent with previous results. Surprisingly, visual field width does not show any effect on estimates, and standard deviations are not significantly higher on the simulator.

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Automatic generation of 3D road networks for driving simulators

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Abstract

Part of the driver's behaviour is the acquisition of informations from the surrounding environment. In the case of a driving simulator, these informations are provided to the driver by various types of devices (projection of an image sequence on a screen in front of him, generation of acoustic signals, ...).

The visual representation is obtained by constituting a 3D database, and then by a 2D projection on a screen. Such databases used on simulators are at present mainly manually generated. The existing tools on the market (modelers) don't deal, most of the time, with road junctions.

The cost of the realisation of a simulator experimentation is greatly linked to the 3D database production. Any step forward in this domain allows to improve the rentability of the simulator.

In the framework of the INRETS project ARCHISIM, we have developped algorithms that enable to automatically produce the database representing a road network. This netwok can be complex, and it may contain equiped cross-roads and round-about. The either real or virtual modelised road network can then be integrated to a ground, real or virtual too.

The particularity of our approach is to be based upon several levels of description of the network : geometric, topologic and symbolic. This approach guarantees the coherence of the representations needed by the simulation models. It allows therefore the driver of the simulator to fully interact with a "realistic" trafic.

These researches now form the subject of a collaboration between INRETS and OKTAL, which is a company specialised in simulation and computer graphics. The goal of this collaboration is to elaborate in the near future an industrial software that would allow fast databases creations for simulator experimentations.

In this speach, we will first explain the necessity to produce coherent databases dedicated to both visualisation and traffic simulation. Using concrete examples, we will then describe our approach. Finally, we will introduce the industrial version of the tool and the future developpements.

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Experimental protocols description language for driving simulators

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Abstract

Simulators have became a way of improving the knowledges in the field of car driving. The researches that may be carried out with these kinds of tools deal among others with road safety, and in particular with driver's behaviour and road infrastructures.

There are numerous advantages linked to studies with a simulator : absence of risk, reproducibility of situations, strict control of the experimental parameters, gain of time, decline of the experimentation costs.

The cost of an experimentation with a simulator is largely linked to the implementation of the experimental protocol on the simulator.

An experiment on simulator consist most of the time in placing a population of subjects in a given situation and to read a certain amount of parameters.

In the framework of the INRETS projects ARCHISIM and SIM, we have developped an experimental protocols description language. This language allows :

- to specify the behaviour of the various actors of the situation
- to sequence the trials
- to deal with checks cases (no respect of the instructions by the subject, for example).

The specifications of this language come from an analysis of the needs that have been identified through the studies carried out in the past by the researchers in human factors of INRETS. The recent experimentations, realised by using this language, allowed to validate our concepts.

In this speach, we will first introduce the concepts handled by the language. Then we will explain, using concrete cases, the way of translating an experimental protocol in an experimentation scenario on simulator.

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A Historical Perspective of the Use of Driving Simulators in Road Safety Research

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The use of driving simulators in their present form is a relatively recent phenomenon in behavioral research. This technology evolved from very simple mechanical and video devices by adapting new technologies derived from flight simulation. Driving simulators have the advantages of providing a task which mimics real driving while at the same time allowing for a level of experimental control which would be impossible in a real traffic environment. Among the advantages of this research tool are that it enables researchers to assess driving performance under conditions that would be too dangerous to carry out in real traffic situations, as well as to test the effects of new in-vehicle and roadway technologies before they are actually implemented. It is precisely these types of conditions--driving under the influence of psychoactive substances, or in hazardous situations such as night driving or in fog; while using new devices such as head-up displays and mobile telephones, testing the effects of new road markings, signs or signals-- which constitute some of the topics in which experimentation using driving simulators has contributed to research in road safety.

This paper describes the evolution of the use of driving simulators in traffic and road safety research during the past twenty four years. The methodology used to quantitatively analyze this evolution was based on an extensive literature search of the articles included in the American Psychological Association's database, Psyclit, between 1974 and 1997. This literature search uncovered 118 empirical studies which employed driving simulators, approximately half of which were published in one of five scientific journals. The criterion for the selection of these articles was that they include at least a steering task as part of the driving simulation.

Based on these articles, two types of analyses were carried out, one regarding the evolution of research topics and another concerning the evolution of the simulator itself. The results of the first analysis provide a classification of the topics which have been studied using this research tool, including most frequent applications, classic areas of research and recently emerging areas of investigation. In addition, the relationship between these topics and those found in other general survey studies of traffic and road safety research are discussed. The second analysis offers a classification of the different kinds of simulators employed, based on the type of visual display (motion picture, computer generated, etc.), degree of fidelity with regard to the physical environment, and degree of interaction between the driver's input or control operations (e.g., steering, braking, accelerating) and the simulator's output.

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An Architecture for Optimal Management of the Traffic Simulation Complexity in a Driving Simulator

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The use of traffic scenarios has been an emerging topic in driving simulation during the last few years, mainly due to the extended range of applications regarding road safety and human factor issues, that require to consider the interaction among several agents. Before that, the traffic simulation was mainly addressed by traffic engineers and robotics researchers. The first group is concerned about the overall evolution of the traffic and their studies focus on the design of new traffic infrastructures and control strategies, and many times this involves the use of models for individual drivers (microsimulation). The goal of the second group is to approach the design of a fully autonomous driving system. Although both fields offer contributions to traffic simulation, there are still some special requirements that have to be considered to achieve a good performance in traffic scenarios for driving simulation. These requirements are real-time execution, 'natural' visual appearance and repeatability of scenario conditions.

A commonly accepted structure for the driver model is based on splitting the driving task into three levels: the *strategic level*, in charge of high-end decisions that affect mainly path planning and route selection; the *tactical level*, at medium decision level, affecting the choice of short terms tasks, like selection of the lane, safe speed, etc.; and the *operational level*, related to the control of the actual performance of the current basic task, like lane change or speed control. The simulation of every single car in the scenario plus the need of a quite accurate simulation of the driving performance is computationally very expensive. The work presented here proposes an architecture that tries to minimize the overload produced by the traffic simulation and, at the same time, considers the different decision levels present in the driving task.

The architecture is based on a Hierarchical Object Oriented approach, defining three behavior levels represented by Server Objects: Strategical and Scenario Control Server Objects, Tactical Server Objects and Operational Server Objects. A fourth level has been introduced on the top of the hierarchy to manage the computational complexity of the simulation. This controller takes advantage of the fact that the driver has different perceptions of the vehicles present in the simulation sceneario, depending on their distance or position. This allows the simulation system to select among a number of accuracy levels to control de behavior of different cars. For instance, a lane change can be performed in a one-step way if the car is out of the field of view of the human driver. However, if the car is just in front of the driver, an accurate steering model is required to perform that task. The Behavioral Level of Detail Manager is in charge of such complexity control by using the different alternatives of the three forementioned levels of server objects.

This software architecture has been used in a set of experiments at the Nissan Cambridge Basic Research Center (MA. USA) to study the degree of comfort of Automatic Cruise Control systems. In these experiments, more than a hundred vehicles were controlled simultaneously without a noticeable computation overload.

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Multimodal driving Simulation in Realistic Urban Environments

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Reproducing the real multimodal traffic of a city, as completely as possible, implies the simulation of autonomous entities like living beings. Such entities are able to perceive their environment, to communicate with other creatures and to execute some actions (drive a car or walk in the street for example). To perform a simulation composed of a large set of dynamic entities evolving and interacting in a complex environment, we need to implement different models: environment models, mechanical models, motion control models, behavioural models, sensor models, geometric models and scenario.

Databases for virtual environments are often confined to the geometric level, when they must also contain physical, topological and semantic information. Accordingly, we have developed VUEMS, a Virtual Urban Environment Modelling System. The main aim of VUEMS is to enable a virtual copy of real cities to be built as realistically as possible and in the initial project in the city of Rennes (France), for driving simulation. After the interactive description of the road-network, based on cartographic data, VUEMS produces two complementary outputs: the 3D geometric representation of the scene and its symbolic representation used by sensors and deliberative agents.

From our point of view and in accordance with some psychological studies, different paradigms are required to describe a deliberative behavioural model (the brain part of a complete entity). This model should be both cognitive and reactive, treating flows of data to and from its environment, in a complex way needing modularity, concurrency and hierarchy, and involving task control and pre-emption. To describe realistic behaviours, we have proposed to use a formal model based on Hierarchical Parallel Transition Systems (HPTS). It has been implemented in a description language that is able to generate efficient C++ code for GASP, our Simulation Platform.

The main objective of GASP is to give the ability to simulate different entities composed themselves of different modules in different hardware configurations, without any change for the animation modules. GASP takes into account real time synchronisation and data communication between co-operative processes distributed on an heterogeneous network of workstations and parallel machines. In order to implement these different models into a unique system, we have designed an object oriented programming methodology.

The purpose of this paper is to present a complete programming environment devoted to simulation and in particular to driving simulation.

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SOFTWARE CHALLENGES FOR LOW-COST HIGH-FIDELITY DRIVING SIMULATORS.

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ABSTRACT

The cost of hardware typically employed in high fidelity driving simulators has been steadily declining. This decline has made it possible to design and construct driving simulators at a fraction of the cost of what was possible, even within the last few years. This progressive reduction in hardware costs has made simulators affordable for a variety of disciplines for which simulation has been too expensive to be beneficial. Such disciplines include training, highway safety, accident reconstruction, and microscopic traffic simulation. The uses of simulators within these new fields have brought new requirements on the ability of the software that accompanies these simulators. Unfortunately, unlike hardware whose costs have been steadily declining, software costs are increasing. The reason for this increase is twofold. Significant new requirements derived from the disciplines that use high fidelity simulators dramatically increase the complexity of the software. In addition, most users of such simulators require the ability to operate the devices without expensive help from highly experienced personnel. Generally, these users are not experts in simulator related technologies such as visual database modeling or software development and may not have the time or interest in becoming familiar with such areas in order to use a simulator. To satisfy the requirements of such users, simulators should be accompanied by software that is user friendly, hosted on low cost platforms, yet is powerful enough to take full advantage of the capabilities of the simulators. This paper reviews the requirements of high fidelity driving simulator software as seen from the vantagepoint of non-technical users. This software includes tools to rapidly develop synthetic environments, tools to develop and test driving scenarios, online tools for real time analysis and evaluation along with data reduction tools that can be used to make sense of the voluminous data obtained during simulation runs. Short surveys of the current state of such tools in various high fidelity driving simulators are also presented.

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Quantitative pressure controller design for a gas recovery system

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This paper considers the design of a pressure controller to control the suction pressure of a gas recovery compressor. The pressure is controlled by means of a valve in the line between an upstream surge vessel and the (downstream) compressor suction. The design must maintain the compressor suction pressure within manufacturer's tolerances despite significant mass flow disturbances into an upstream surge vessel. This practical application of the QFT design method considers the valve non-linearity, valve actuator and sensor rise times, the approximate effect of distributed gas dynamics, digital implementation issues and the use of a feed-forward measurement of surge vessel pressure. Because of the fast dynamics, the design is required before equipment purchase and installation.

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QFT Synthesis Design for Discrete Flight Control Systems

by
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Abstract

This paper investigates a method to address the present and future flight control system analog IC requirements. The explosive growth in the development of VHDL-AMS (Analog Mixed Signal) has initiated the need for commercial CAD products based on mixed-signal design methodologies. Several design methodologies exist for developing analog-digital interface circuits. These methodologies range from the use of commercial off the shelf parts (COTS) to custom analog Integrated Circuit (IC) components that meet performance specifications. The current VHDL-AMS language has potential problems in the design of custom analog IC components in terms of scaling the internal device dimensions and maintaining robust design performance. As an example, a digital controller is being used in flight control systems. The digital controller is an embedded processor, which, through a D/A, controls the actuators of the aircraft. Sensors from the actuators are fed back through an A/D, a low-pass filter, and then to the embedded processor, completing the loop. In this example, the VHDL-AMS language is used to describe the electronic operational amplifier elements of the flight control system, and also, uniquely, the digital compensator. The digital compensator and filter are designed with the use of Quantitative Feedback Theory (QFT) technique that emphasizes the use of feedback to achieve the desired system performance tolerances despite plant uncertainty and disturbances. The QFT design technique uses the frequency domain, and has been developed for linear and nonlinear, time-invariant and time-varying, continuous and sampled-data, uncertain multiple-input signal-output (MISO) and multiple-input multiple-output (MIMO) plants, and for both output and internal variable feedback. It has been extended to some classes of uncertain distributed systems (in which the plant is described by partial differential equations) and the feedback and specifications are also distributed. The final QFT VHDL-AMS design, is tuned for performance to the bounds of uncertainty,

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the parameter tolerances, and the sampling time of the A/D and D/A, and may be used for either COTS design or custom analog IC components. The design was simulated and fabricated successfully.

SMITH PREDICTOR FOR UNCERTAIN SYSTEMS IN THE QFT FRAMEWORK

M. Garcia-Sanz and J.C. Guillen

CONTROL of systems with a dominant time delay are notoriously difficult. In the last few years many research efforts have focused that particular problem, specially in process control. For open-loop stable processes, the response to command signals and the load disturbance rejection can be improved substantially by introducing dead-time compensation. Perhaps the most popular scheme for such systems is the Smith Predictor Controller *SPC* (Smith, 1957).

The basic control structure of the *SPC* is the model-based approach shown in Fig. 1, where $G(s)\,e^{-s\tau}$ represents the real plant and $C(s)$ a conventional controller. A model of the open-loop process $G_n(s)\,e^{-s\tau_n}$, called nominal plant, is used in an additional feedback loop in order to obtain an open-loop feedback signal that carries current and not delayed information. A simple analysis of Fig. 1 shows that, if $\tau_n = \tau$ and $G_n(s) = G(s)$, the controller $C(s)$ can be synthesised as a standard feedback regulator for a plant described by $G(s)$ only. This allows the designer to improve the closed-loop performances with respect to those achievable by feedback regulator directly designed for the original plant $G(s)\,e^{-s\tau}$. In this manner, the time response of the closed-loop system with a compensator that uses a *SPC* will thus have the same shape as the response of the closed-loop system without the time delay compensated by $C(s)$; the only difference is that the output will be delayed by τ seconds. Indeed, in Astrom (1977) it has been shown that the Smith predictor structure provides a significant phase lead which justifies the above statement.

On the other hand, speaking generally any mathematical model of a real process typically depends on some parameter values q_i that are estimated between lower and upper bounds q_i^- and q_i^+, so that the description of the plant will present some amount of uncertainty,

$$\mathbf{P} = \left\{ P(q) \mid q_i \in \left[q_i^-, q_i^+ \right] \;,\; i = 1, 2, 3, \ldots l \right\} \tag{1}$$

In addition, it is well known that the Smith Predictor technique is extremely sensitive to model mismatch, either in the delay τ_n or in the rational part $G_n(s)$ (Ioannides *et al.* 1979 ; Palmor, 1980 ; Yamasaka and Shimemura, 1987). For these reasons, the design and tuning of a *SPC*, i.e. the selection of the nominal set $[G_n(s),\ \tau_n]$, must take the uncertainty of the plant into account. This paper deals with the development of some criteria for such a problem using a Quantitative Feedback Theory (QFT) design technique (Horowitz, 1991 ; D'Azzo and Houpis, 1995). The *SPC* can be rearranged as shown in Fig 2, where,

$$H(s) = \left(1 - e^{-s\tau_n}\right)\left(\frac{G_n(s)}{G(s)}\right) + e^{-s\tau} \qquad \textit{where} \quad G(s) \in \left[G(s)^-, G(s)^+\right] \;\textit{and}\; \tau \in \left[\tau^-, \tau^+\right] \tag{2}$$

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The $H(s)$ term that appears out of the control loop is the responsible of the deterioration of the system characteristics. In that context an analysis of the frequency response of $H(j\omega)$ can be very useful, as shown in Santacesaria *et al.*(1993). Any increase in model mismatch would move the resonance peaks to lower frequencies, reducing the bandwidth of the system.

For this reason, the *first proposed criterion* is to search a nominal set $[G_n(s), \tau_n]$ for the *SPC* that maximizes the minimum bandwidth of the set of $H(j\omega)$ over the uncertainty, produced with that selected nominal set, i.e. that minimizes the expected model mismatch.

Now, if the required closed-loop bandwidth is lower than the calculated above for a collection of possible nominal sets, then an additional degree of freedom is still available to choose within this collection. That additional degree of freedom will be used as a *second criterion* in order to take advantage in the QFT design technique of the $C(s)$ controller.

To be more precise, the new target deals with the analysis of the change suffered by the QFT plant templates when a *SPC*, with a particular nominal set $[G_n(s), \tau_n]$, is included in the controller structure. Figure 3 shows two templates for the same frequency corresponding to two different nominal sets. That will lead to the question of what is the optimal nominal plant to be selected that minimizes the resulting templates, i.e. makes easier the loop shaping, within the constraints given above from $H(j\omega)$.

To analyze the real performance behaviour of the proposed methodology, a set of *SPC* and QFT control strategies have been implemented on a laboratory-scaled High Temperature Short Time (HTST) Pasteurisation Plant. The final results show that the proposed methodology can be used as a tool to improve the control of Time-delay systems with uncertainty.

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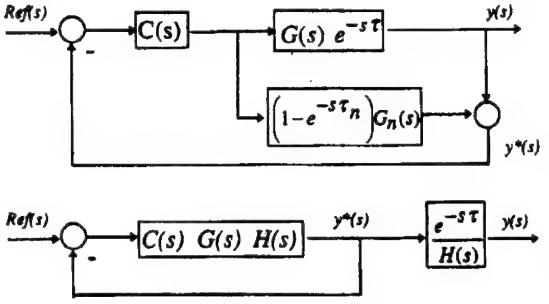

Figure 1

Figure 2

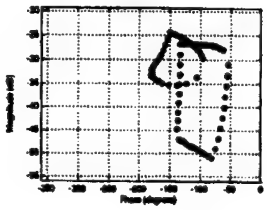

Figure 3

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QFT-CONTROL OF A BIOLOGICAL REACTOR FOR SIMULTANEOUS AMMONIA AND NITRATES REMOVAL

M. Garcia-Sanz and J.X. Ostolaza

ONE of the most important objectives of a Wastewater Treatment Plant (WWTP) is to protect the water environment from negative effects produced by residual water, controlling the maximum concentration of pernicious substances. This paper presents the design of a two loops control strategy, based on the Quantitative Feedback Theory (QFT), and their implementation on the Activated Sludge Wastewater Treatment Plant of Crispijana (Vitoria, Spain), with a Nitrification-Denitrification (D-N) configuration, whose diagram is showed in Figure 1.

The overall control objective is to minimize simultaneously the effluent nitrogen compounds (Ammonia -*SNH*- and Nitrates -*SNO*-) discharged from the plant, in spite of disturbances.

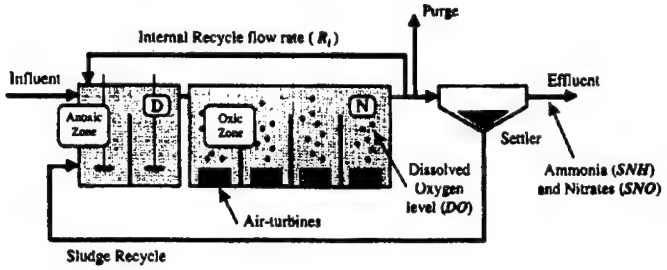

Fig. 1. Wastewater Treatment Plant

Nitrification is the bacterial oxidation from ammonia to nitrates by nitrificant bacteria. On the other hand, Denitrification is the process that reduces nitrates to gas compounds of nitrogen by micro-organisms which use these components instead of oxygen in the respiration process when oxygen falls short.

The biological reactor presents two zones. The first one (D zone) has no aeration system. It must eliminate the organic material in the influent water using the nitrates as an oxidising agent (Denitrification). The second zone (N zone) is aerated and eliminates the rest of the organic material and the ammonia (Nitrification). The plant configuration needs an internal recycle to support the Denitrification process. This recycle supplies nitrates from the nitrification stage to the denitrification zone.

The open-loop system of the WWTP is showed in equations (1) and Figure 2.

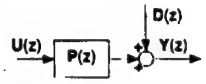

Fig. 2. Block-Diagram of the open-loop system

$$Y(z) = P(z)\,U(z) + D(z)$$

$$\text{where,}\quad P(z) = \begin{bmatrix} P_{11}(z) & P_{12}(z) \\ P_{21}(z) & P_{22}(z) \end{bmatrix};\quad D(z) = \begin{bmatrix} d_1(z) \\ d_2(z) \end{bmatrix};\quad Y(z) = \begin{bmatrix} y_1(z) \\ y_2(z) \end{bmatrix};\quad U(z) = \begin{bmatrix} u_1(z) \\ u_2(z) \end{bmatrix} \qquad (1)$$

where $u_1(z)$ represents the Dissolved Oxygen level -*DO*- and $u_2(z)$ the Internal Recycle flow rate -*Ri*- (the plant inputs); $y_1(z)$ represents the instantaneous effluent ammonia concentration -*SNH*- and $y_2(z)$ the instantaneous effluent nitrates concentration -*SNO*- (the plant outputs); and $d_1(s)$ and $d_2(s)$ the effect of the instantaneous ammonia and nitrates load inflows at the outputs of the plant $y_1(s)$ and $y_2(s)$.

In this manner, the controller considers the plant as a multivariable 2x2 system, where the output variables are the nitrates *(SNO)* and ammonia *(SNH)* concentrations at the outflow, and the input variables the desired Dissolved Oxygen *(DO)* level and the suitable Internal Recycle *(Ri)* flow.

Alternatively, the well known theory of the Relative Gain Analysis (RGA) provides a methodology to select pairs of input and output variables in order to minimize the amount of interaction among the resulting loops. Accordingly to such a method, it is possible to decouple the two loops, using the *DO* level as the input variable to control the ammonia *(SNH)* concentration at the outflow (first loop) and the Internal Recycle flow rate as the input variable to control the nitrates *(SNO)* concentration at the outflow (second loop).

On the other hand, there are two models of the Wastewater Treatment Plant used in this paper for the proposed application. The first one describes the biological process by using the mathematical model developed by the IAWPRC in 1983 *(A-model)*, which presents a multivariable and non-linear system with 34 states. It was calibrated with real data of the WWTP of Crispijana (Spain).

The second model *(B-model)*, showed in equation (2), presents a linear structure, with one zero and two poles. It describes the dynamics of the process considering the complexity as parameter uncertainty.

$$P(z) = \left\{P_{ij}(z)\right\} = \frac{c_{ij} + d_{ij}\,z^{-1}}{1 + a_{ij}\,z^{-1} + b_{ij}\,z^{-2}} \qquad i = j = 1,2 \qquad (2)$$

The parameters (a_{ij}, b_{ij}, c_{ij}, d_{ij}, $i = j = 1, 2$) of the *B-model* were estimated from computer simulations of the complex model (*A-model*) with seasonal temperature variations, changes in the load inflow and in the influent flow rate of the plant (±50%), and variations in the *DO* level and the *Ri* flow rate, resulting a set of 10,000 operating conditions.

The development of such a model allowed to design the QFT controllers of the two loops, making easily the templates, the robust stability and the disturbance rejection bounds, and the loop-shape of the controllers. The design was made keeping in mind the energy saving in the plant operation.

The behaviour of the final algorithms was investigated implementing them in a computer simulation with the *A-model* and running both control loops simultaneously. The results obtained here show that Quantitative Feedback Theory (QFT) control, when applied to the activated sludge process, allows for a tighter control of the average of the *SNH* and *SNO* values. This comes along with a significant reduction of the Dissolved Oxygen demand, which is another objective -energy saving- at every municipal wastewater treatment facility. The controllers developed are also suitable for low-cost microcomputer implementation.

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Frequency Dependent Tools for Control Structure Design and Diagonal Dominance Improvement for Decentralised Control

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ABSTRACT

In this paper well established frequency dependent tools dealing with the pre-conditioning of a Multi-Input/Multi-Output (MIMO) system are reviewed. These tools consider the problems of Input/Output (I/O) selection, I/O assignment or pairing and the reduction of interaction, which are important parts of multivariable decentralised control design methods such as the Direct Nyquist Array (DNA), the Characteristic Locus, the Quantitative Feedback Theory (QFT), and the Sequential Loop-Closing (SLC) methods. Since some of these tools are scaling dependent, I/O scaling algorithms will also be discussed. I/O selection is the problem of choosing the variables which are the most appropriate to control as well as most effectively controlled. In some cases for instance, a number of measurements are available and a particular closed-loop specification can be defined in terms of the control of several of these measured variables. However, the number of independently controlled outputs can not be greater than the number of inputs, and hence the designer might prefer to square the system down, selecting from the available measurements the most appropriate ones. I/O assignment or pairing is the procedure where each input (or set of inputs) is assigned to the control of a particular output (or set of outputs). These two problems define the so called Control Structure Design. A good physical understanding of the plant to be controlled is always an initial step in the solution of these problems. However, in many cases the designer is still left with more than one choice, from which the best according to some criteria

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should be chosen. This is the case in many real world applications, as for instance in aircraft and process control system problems. A systematic solution to these problems is obviously of paramount importance, especially in the design of MIMO decentralised control systems. If an input is to be paired with an output over which it has a little or no influence, then clearly satisfactory control would be unattainable. Also, the magnitude of the I/O pairing problem varies factorially with the number of independent inputs. For instance, assuming square systems, if the number of inputs is two, there are only two possible configurations. However, if the number of inputs is five, there are 5!= 120 possible pairings, which shows how quickly the problem explodes in size. Of course, many of these combinations will incorporate control loops that are intuitively ineffective, and therefore can immediately be disregarded. Even so, the remaining number of combinations might be sufficiently high that they require the use of algorithmic type of solution.

Non-minimum phase characteristics, and high-levels of interaction are common problems in control systems design that could possibly be reduced, or even avoided, by choosing an alternative control configuration. More specifically, right half-plane (RHP) zeros can be a cause of concern if they lie within the closed-loop bandwidth that the designer is aiming for. Different choices of outputs could give rise to different RHP zeros. The best choice would be the configuration with the minimum number of RHP zeros, located as far from the imaginary axis as possible. The Relative Gain Array (RGA), developed by Bristol over thirty years ago, has found widespread use as a measure of interaction and as a tool for control structure design. As originally presented, the RGA involved only steady state considerations, but more recently several investigators have considered dynamic extensions of the RGA. The RGA has nice properties, the main one being its independence of input and output scaling. Engineering practice has been shown that choosing pairings which result in large or negative elements in the corresponding RGA, leads to difficulties in controlling the plant. Moreover, the I/O pairings should be chosen such that the diagonal elements of the RGA are as close to unity as possible. A generalisation of the RGA to block pairing of inputs and outputs, which are not necessarily single-input/single-output (SISO) systems, is the Block Relative Gain (BRG).

NONLINEAR QFT BASED ON LOCAL LINEARIZATION

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ABSTRACT

Existing nonlinear QFT techniques are based on some form of linearization of the nonlinear plant, where the validity of the nonlinear control design is guaranteed by the goodness of the equivalent linear design. In this work we investigate a different approach to nonlinear QFT, based on the local linearization of the nonlinear plant about closed-loop acceptable outputs. Here, acceptable outputs appear as uncertain parameters in the equivalent linear plant, being a generalization of the more traditional linearization about equilibrium points. A comparison of this technique with the previous ones is made, using significant examples to emphasize design properties, control effort, and computational tractability. Two examples are analyzed in detail: the uncertain Van de Pol plant considered previously in the QFT literature, and a pH control system.

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IMPROVEMENT ON THE COMPUTATION OF TEMPLATES IN NONLINEAR QFT

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ABSTRACT: In previous papers, the authors have developed some results about the selection of acceptable outputs for the design of robust linear controllers for nonlinear and/or time-varying plants (NLTV), in the framework of QFT. This selection is made by constructing a finite ε-net for the original (infinite) set of acceptable outputs, a compact subset of the Banach space RH_∞, and thus, the ε-net is built using the H_∞ norm. Although these results are theoretically correct, and provides QFT with a valid and mathematically formal method for selecting finite sets of acceptable outputs, it turns out that the method is numerically ill-conditioned for many interesting practical nonlinear control problems.

In this work, the authors describe all these numerical problems and propose a new technique for discretizing sets of acceptable outputs. The technique is based on a redefinition of signals spaces, including a norm that weights signals over a frequency logaritmic scale. As a result, the computation of templates becomes cleaner and, overall, is very efficient in terms of computation time.

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EUROPEAN CONSORTIUM STUDIES ON INTELLIGENT FORECASTING

Berthold Bitzer

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Fachbereich 16: Elektrische Energietechnik
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Soest, Germany

The European Union funds the thematic network for intelligent forecasting systems (IFS) by the Brite-EuRam program. This program is in the field of industrial and material technologies. The network brings together industry and universities all over Europe for cooperation in forecasting systems of refineries an power systems. This contribution describes the general tasks, objectives, and worksteps associated with the subproject of forecasting in industrial and power systems.
Besides this first results of the cooperation project between the University of Paderborn and the local distributor of the German town Dortmund are presented.

The Situation

In January 1995 the power distribution of the German town, Dortmund changed from the regional power distributor VEW to the local distributor who is now responsible for the gas, water and power delivery. The power generation is still realized from VEW. The calculation and costs of the energy import is fixed on a contract that is based on the average of the three largest peak loads in a year. The local distributor dispose of small own energy capacities for a short time. They are able to reduce load peaks if the energy demand is known in time. Up to now, load forecasting is done empirically and experiences with different load forecasting techniques are missing. A computer operated Supervisory Control and Data Acquisition (SCADA) will be installed, including load forecasting elements based on regression methods.

The Project

The cooperation project has the aim to examine the practical use, advantages, disadvantages and differences of regression methods and neural networks for a 24 hours load forecasting in Dortmund. Therefore 15 minutes - load data from two years are available as well as weather information like temperature, wind speed and clouds from two weather stations in this region.

In a first step an overview of the data analysis will be given to determine the influence of historical load data and temperature on the load demand for the next 24 hours. Based on this information the inputs for both methods will be set. In a next step the results of a 24 hours load forecasting with neural networks and a multiple regression for three exemplary months will be shown and the results will be discussed. Improvements, advantages and disadvantages in the use of one of these methods will be presented.

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"DAPHNE" a Neural Network based Short-term Load Forecasting Program. Application to an Autonomous Power System.

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This paper presents "DAPHNE" a Neural Network based short-term load forecasting software package. Forecast results for software's off-line application to an autonomous power system are also reported.

The short-term load forecasting model is based on a fully connected three layer feedforward Neural Network (NN). The NN has 64 input neurons, 48 hidden neurons and 24 output neurons representing next day's 24 hourly forecasted loads. Temperature is a crucial parameter that affects load consumption behaviour, therefore, it plays a key role as an input to the NN. Both historical and forecast temperature and load data are employed in the NN input set.

Short-term load forecasting in an autonomous power system proved to be a rather difficult task due to frequent irregularities in the available historical load data. It was found that almost 2.5% of load data were missing or disturbed and finally replaced by the introduced pre-processing procedure. Load data are missing or are false due to unrecorded samplings or to bad measurements. In the case of the autonomous power system we examined, irregularities in load data are also due to the frequent load interruptions, especially during the summer months, attributed to delays in constructions of new generating plants.

In order to overcome these difficulties "raw" historical load data are pre-processed before they are introduced to the NN either as training patterns or as test inputs. Data pre-processing is one of DAPHNE's subsidiary functions.

In real time applications, system operators at the dispatch center forecast next day's loads at an hour between morning and noon handling incomplete current day load information. To overcome the problem of incomplete data, an auxiliary NN is used to predict the missing loads. Afterwards, the basic NN model is employed to forecast next day's load curve.

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IFS APPLICATIONS TO LOAD FORECASTING IN THE EPS OF CYPRUS

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ABSTRACT

Thus far, the experience of the operations department of the Electricity Authority of Cyprus (EAC) on Intelligent Forecasting Systems (IFS) applications on Load Forecasting (LF) is limited.

Today, a Supervisory Control and Data Acquisition (SCADA) / Energy Management System (EMS) is running and the last substations are in line to be connected this Spring. The System connects to the Control Center in Nicosia all generating stations, transmission substations and all primary distribution substations for data acquisition and control through sophisticated software for the efficient operation of the Electric Power System (EPS).

An IFS predictor facility developed by ABB's System Control based on Artificial Neural Networks (ANN) is now being trained and fine-tuned within the SCADA. This tool takes into account past loads and other measurements such as temperature, humidity and luminescence as well as special days/events and makes short-term LF, medium-term LF as well as long-term LF.

In the past, a Short Term Load Forecasting (STLF) tool developed by Systems Europe was used for peal-load predictions. The system was based on Kalman Filter and was restricted in the input parameters.

In this paper, the author describes the characteristics of the software used and the model training presently under way and assesses the experience thus far.

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LOAD FORECASTING PRACTICES AT THE DISPATCH CENTER OF CRETE

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ABSTRACT

In recent years the Electricity Dispatch Center (EDC) of the Electric Power System (EPS) of Crete, located in a suburb of Iraklio, has operated a Supervisory Control and Data Acquisition (SCADA) system developed by AMBER and efforts have been made to add an on-line forecasting tool as a dispatcher's-aid to the system control.

So far, Short Term Load Forecasting (STLF) is done based on operator experience. Measurements of loads, temperature, etc. are logged every minute into a database. Load curves are drawn on 24-hour basis. Experienced operators predict forthcoming load demand taking into account judiciously chosen recent-past load curves. It has been observed that for the autonomous EPS of Crete local special events play a crucial role in shaping the electric demand and this knowledge is integrated in the forecasting practice.

The safety margin for load predictions is between 5 to 10 MW depending on the time of prediction or the type and power-rating of the standing-by generating units.

This paper analyses the load forecasting practice at the EDC of Crete and determines the relevant elements of this approach that can be used in the foreseeable future for an intelligent forecasting system operating on-line within the SCADA.

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CRITICAL FACTORS IN LOAD FORECASTING FOR THE AUTONOMOUS EPS OF CRETE

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ABSTRACT

The utility and adoption of a prediction-of-demand model in an autonomous Electric Power System (EPS) such as that of Crete is of great current interest due to the probable consequences it may have for the safety in the system operation, the quality of the electric power supply and the general economic state of the region.

The solution of the problem of maintaining the balance between generation and power demand in the EPS of Crete, in view of the large 24-hour variations of demand and the peculiarities of the generating units, should reduce to a minimum the probability of operational disorders in the grid which would jeopardize the safety of the system and at the same time show the possibility of supplying electric power in the most economical way while satisfying the technical restrictions.

In this paper, firstly, a summary of the characteristics of the Cretan EPS and the requirements of the problem at hand is given. Then the authors make a study of the factors that must be taken into account in the formation of a suitable database for the prediction of power demand according to logged parameters and the operator's experience. We explain the mechanisms by which the above mentioned factors affect the fluctuation of power demand and an effort is made to determine the relative importance of the contribution of each factor.

Conclusions are drawn about the required levels of accuracy of prediction of the power demand for the EPS of Crete, to assure practical usefulness, and the optimum presentation of forecasting to assure user-friendliness.

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REVIEW OF ANN BASED LOAD FORECASTING RESEARCH FOR THE EPS OF CRETE

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ABSTRACT

The present paper reviews the considerable volume of research done in the last five years on Artificial Neural Networks (ANN)-based Load Forecasting (LF) for the Electric Power System (EPS) of Crete that has eventually led to the formation of an European Union Brite-Euram Program-sponsored Intelligent Forecasting Systems (IFS) Thematic Network for Power Systems and Refineries.

The importance of reliable Short Term Load Forecasting (STLF) for the Energy Management System (EMS) of the autonomous EPS of Crete has been clearly shown. Different network architectures, activation functions and learning rates have been tried aiming at finding the network that results in the best possible estimations, considering the necessity and the effects of normalizing the input and output data as well as the real difficulties to select reasonable data-scaling values.

The criteria of acceptance of LF outputs as well as databases and inputs have been of great concern. Questions such as (a) what constitutes an acceptable accuracy of prediction relative to the particular characteristics of the EPS and (b) which are the critical parameters for effective LF are intensively researched.

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FORECASTING USING KNOWLEDGE BASED TECHNIQUES AND ARTIFICIAL NEURAL NETWORKS

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SUMMARY

This paper presents a forecasting system that is based on Knowledge Based techniques and Artificial Neural Networks (ANNs) for demand forecasting. Most techniques used for forecasting can be categorized under three main categories. The first treats the demand as a time series and predicts the load using different time series analysis techniques. At the time series forecasting approach several methods have been developed to give different validity to more recent data (like for example the exponentially smoothing technique), to monitor the forecasting error and to adjust the smoothing factor to the evolution of the forecasting error using Trigg's warning signal. General problems with the time series approach include the inaccuracy of prediction and numerical instability due to the lack of information about external factors that influence the model and which are not included in the time series previous historical data.

A second approach is based on regression techniques which accept that demand is heavily dependent upon external factors. Using linear or non-linear regression analysis a functional relationship is created between the demand and selected external variables. However, this relationship usually depends also upon temporal past data making the relationship non-stationary temporal dependent.

A third approach that has appeared more recently is based on Artificial Neural Networks (ANNs). It is a very interesting approach that gives sufficient results with small forecasting errors. The ANNs can generate the forecasting result after they have been trained and have learned from past historical data, that might concern temporal or any other functional relationship between the model's inputs and the real demand of previous historical periods. ANNs during the training phase require heavy computations until they minimize the forecasting error, arriving at a state which corresponds at a global minimum of the error function. After the training, the ANN is used to forecast the demand for future time periods. The Multi-Layer Perceptron (MLP) using the Backpropagation algorithm for training the network is one of the most common Artificial Neural Networks used for forecasting. In most cases the ANNs are trained with a large amount of data from the past, in an effort to provide to the network information that covers as much as possible the relation between outputs and inputs of the model that the network represents. No-emphasis is given at the relation that exists between the size and the kind of the training data set with the evolution of the error at each forecasting period. Usually the mean error is the index of the network's performance and not the maximum error values. Also the large amount of training data makes the continuous retraining generally difficult and almost impossible in short-term forecasting where the time period is rather short (for example an hour).

The proposed here forecasting method uses Knowledge Based techniques to monitor and record the error evolution and when this is necessary to select a new data set with more appropriate and efficient data for retraining the Neural Network. This new selection of data sets is based on knowledge that concerns the error evolution, the validity of the most recent data on the Neural Network model, and the creation of the appropriate sample of data to retrain the network. By this way there exists a continuous monitoring of the forecasting error, a retraining of the network with new data that depends on the evolution of the error and a minimization of the size of the training data set. This minimization of the size of the data set is necessary for the method to be time efficient because of the continuous retraining of the network.

The Knowledge base contains rules for selecting the data set in relation with the evolution of the error. These rules concern the data set size, the independence of data, how long in the past we shall move, how many values we shall use, what validity we shall give on the most recent data and generally how we shall use the data which are distributed over time. The evolution of the error in time plus the characteristics of previous used training data sets are the inputs to the knowledge base, which provides as inference result the most appropriate data set. This continuous monitoring and recording of the error evolution, in relation with the previous inference results, may also provide the knowledge base with new knowledge in the form of data and rules that can be used in future inference processes.

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Driving simulators as research and training tools for improving road safety

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Abstract

This paper will focus on the contribution of driving simulators to the improvement of road safety when used either as research and/or training tools. It is well known that research driving simulators provide an inherently safe environment which can be easily and economically configured to investigate a variety of human factors research problems. In addition training car and truck simulators can train less expensively and they are safer and faster than using the actual vehicle. They do not consume energy, they do not need as much maintenance as the real vehicle and they are environment-friendly. This paper will highlight research, training as well as demonstrative ways of using driving simulators to tackle the problem of road safety in Greece.

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Viewing Strategies in Curves during Simulation and Reality

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Abstract

In keeping the vehicle within the lane boundaries, the driver has to fulfill different tasks that mainly rely on visual information. In this context the ability of well-timed aquisition and processing of information is an essential issue. In the case of curve negotiation the availability of visual information about further road geometry plays a vital role for the quality of the driver's steering behaviour. As many studies (Cohen, 1985; Shinar, et al., 1977; Land & Lee, 1994) have shown, drivers use the tangent point on the inside of the curve as an informational unit to follow road curvature. The viewing distance relative to their own position is dependent on driving experience; experienced drivers look ahead about one second into the „future" (Land & Horwood, 1995; Löwenau & De Vos, 1997).

In this paper, results are presented from a study that explores the validity of visual behaviour in a driving simulation and real test rides. Ten subjects completed test rides in a simulator and on-the-road, both on a similar two-lane test route that included curves. Each trial (real vs. simulator) was performed three times in daylight conditions. During the sessions eye movement behaviour was recorded via the Applied Science Laboratory (ASL) Eye-Tracking-System (ETS). Measurement instrumentation and measurement algorithms were re-designed and new calibration algorithms were developed. Results show very clearly that subjects use the same cues (lane markers) and very similar systematic viewing strategies during curve negotiation in reality and in simulation. According to the results the driving simulator seems to be a useful tool for further studies concerning the investigation of driver's visual behaviour.

The full paper describes results of a driver assistance system (development of moveable headlamps) and identified viewing strategies.

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Research and development simulator using head mounted display

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Automotive driving simulators have been developed at Renault, Direction de la Recherche for on-board safety system design, testing and ergonomics assessment since 1987.

Committed to road trafic safety, Renault has also initiated and managed the European Truck and Coach Simulator (TRaCS) project (Eureka n. 1238). TRaCS consortium members were the French AFT and TT&S, the Dutch VT&L, the Norvegian Autosim and the Swedish Clarus.

For both research and development and training simulators Renault has given special attention to display systems since 90% or more of the information essential to vehicle control is visually acquired.

Reliability and ease of integration objectives leaded us to investigate solutions based on standard display system technology, without specific optics (i.e. lenses or image correction devices).

Fixed based flat screen display systems were designed with 180° frontal plus triple rearview 6 channel direct projection for passanger vehicule and 210° frontal plus triple rearview 7 channel rearprojection for truck applications. High resolution images are displayed on the frontal screens at 30 to 60 Hz according to image generators characteristics.

Among the new display technologies coming to the market, head-mounted displays seem to be promising for driving simulation needs. Complete immersion can be achieved, the driver being able to explore the virtual world from all viewpoints with stereoscopic view.

With the advent of high performance image generators, displaying a high fidelity textured model of the cabin interior becomes feasible. This allows to use a reduced driver station and to reduce on board inertia - thus adapted to motion rendering - and providing unlimited driver view.

The definition and design of such an architecture is the objective of the European CaRDS (Comprehensive Automotive Research and Development Simulator) project (EUR.1924) which was recently initiated by Renault. Consortium members are the French CNRS and Pons, the Swedish Clarus and the UK SEOS companies with Renault, also responsible for the managment of this project with a 3 years' duration from May 1st, 1998.

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ITERATIVE MODEL BASED H_2/H_{INF} SYNTHESIS FOR ACTIVE SUSPENSION SYSTEM

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In this paper an iterative identified model based mixed H_2/H_{inf} control synthesis is proposed for active suspension design. Since the identification criterion depends on the controller of the closed loop system and the controller design depends on the identified model, therefore these problems are incorporate with each other. According to this principle an iterative method is proposed which applies weighting strategy both in the identification step and in the control design step to create conformity between the control law and the identification criterion. The weighted identification criterion applies information from the closed loop system, and the weighted control design criterion applies information from the identified model and of the uncertainty.

In the classical approach an LQG criterion is applied that is based on a quadratic sum of dynamic tire load variation, the sprung mass acceleration and suspension working space. In our approach mixed H_2/H_{inf} control synthesis is applied which minimizes an LQG performance index while a slightly suboptimal H_{inf} controller is preferred over an optimal one. In this method the LQG criterion is expanded by an H_{inf} criterion on the minimization of the injurious vibration caused by external disturbance. Moreover, a loop transfer recovery (LTR) method is proposed to reach the desired loop in the case of uncertain components. In this method the desired loop shape can be reached by tuning two parameters, namely the γ parameter in the H_{inf} synthesis and the μ parameter in the LTR approach. Applying the H_2 norm versus H_{inf} norm curve that γ value can be selected, which reduces the H_{inf} norm significantly with little increase in the H_2 norm, therefore it gives trade-off between stability robustness and quadratic performance. In the iterative scheme the control design is served by model identification, since the purpose of the identification process is to minimize the so-called performance error criterion, that is based on the difference between the designed closed loop and the actual one. In our approach weighted least squares criterion is applied, which results in a model for controller design.

The iterative scheme is demonstrated throw an active suspension design. The task of design is to find the internally stabilizing compensator, which minimizes the effect of the injurious vibrations due to the road roughness and the on-board rotating components. The algorithm of the iterative method is illustrated step by step.

KEYWORDS: robust control, mixed H_2/H_{inf} synthesis, closed loop identification, uncertain system, active suspension design.

A SKYHOOK CONTROLER FOR THE ACTIVE VIBRATION CONTROL OF A VEHICLE SEAT

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The vibration load on the driver of a vehicle has several negative effects. Besides contributing to physiological changes in the back and joints, the vibrations also cause other types of discomfort. Further consequences are a lower quality of the performed job and a lower degree of utilisation for the machine. Although in automotive engineering several active suspensions have been developed, the achievement of comfortness for the passengers seems to be easier achieved with active suspension seats.

At the present work an active control algorithm has been developed, constructed and validated in the laboratory and in -situ tests for several road profiles. The major limitations to the controller was set by an innovative variable reluctance actuator which is the power supply to the active suspension. The variable reluctance actuator's gap is only 9 mm maximum and it is coupled in parallel with a very stiff spring (300 N/mm) for the static load compensation. Moreover, the performance of the actuator is strongly non-linear requiring an additional controller for its operation.

The skyhook controller is perfectly suited to such systems as it is very stable and simple. It is based on the absolute velocity feedback of the moving part i.e. the seat, giving to the system a naturally damping behaviour. The skyhook controller is an inherently active system as this damping behaviour is like a passive damper attached to a fixed point which does not exist. As the most human sensitive frequency range is from 3 Hz to 12 Hz it came up that the absolute velocity feedback affects mainly the mid range part (5 to 12 Hz) whereas the addition of the absolute displacement feedback improves the low range frequencies.

In order to adapt this modified skyhook controller to the present problem (several kind of road profiles, several seats, several passengers) to avoid actuator's saturation (7 mm displacement peak-to-peak and 2100 N max. output force) an innovative adaptive algorithm was developed. This algorithm is based on the prediction of the velocity and the displacement and aims at producing the optimal instant damping force through normalisation. According to this algorithm the feedback state value (velocity or displacement) is divided by the corresponding predicted state value and multiplied by a properly defined constant. The prediction of the states is performed using a simple time gradient. Due to its simple nature the adaptive algorithm requires only a single accelerometer attached to the seat.

The proposed algorithm has been tested extensively on computer simulations and tested in laboratory tests and in in-situ tests proving its efficiency and robustness. Reduction of seat vibrations in the most human sensitive frequency region by 20 dbs in simulations and 10 dbs in in-situ tests show that the system performs very satisfactorily. The main problem comes from the displacement limitations of the actuator and will disappear if a more powerful actuator is employed. Recently in a similar application Stein used a more complicated control strategy with more accelerometers whereas the performance of the system was not as good as the present control algorithm although a more powerful hydraulic actuator was used.

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SELF-TUNING DELTA BASED CONTROLLER FOR AN ELECTROMAGNETIC SUSPENSION VEHICLE

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Abstract:
Vehicle suspension technology using controlled direct-current electromagnet is well established. In most experimental systems, linear state feedback techniques are used to obtain stability and other appreciated suspension characteristics. Because of the highly nonlinear magnetic characteristics, such control system (digital or analogue) necessarily restrict the permissible operating range within the linear domain of the magnetic circuit. As a consequence, dynamic response and the allowable variations in both the airgap and force disturbances are severely restricted. This paper presents a novel self-tuning delta based controller which while stabilising the system, with near critical damping ratio, provides disturbance rejection ability without requiring excessive control current. The theoretical background for the development of the respective adaptive algorithm are presented and implemented on TMS 32020 digital signal processor, a number of illustrative results are included.

Keywords: Electromagnetic suspension, Delta modelling, Adaptive control, Digital signal processors, Real-time control.

1. INTRODUCTION: This paper presents a novel self-tuning delta based controller implemented on a digital signal processor for an electromagnetic suspension vehicle. With the availability of low cost, high speed VLSI devices, use of digital techniques to control the electromagnetic suspension vehicle is feasible. The Texas Instruments TMS 32020 digital signal processor has been used to implement several control algorithms. In this paper the fixed parameters state feedback controller is used to:

a. Develop a self-tuning (digital) algorithm for implementation on the TMS 32020 digital signal processor.
b. Formulate a self-tuning pole placement state feedback algorithm based on delta model operator.
c. Develop fixed point to floating point conversion operations for a self-tuning Delta based algorithms to be implemented on the TMS 32020 digital signal processor for an electromagnetic suspension vehicle.

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GUIDANCE PRECONDITIONING BY AN ARMA SEQUENCE FOR ROBUST RESIDUAL VIBRATION SUPPRESSION

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Residual vibration suppression is quite important in a broad range of mechanical engineering applications: space structures, cranes, textile machines, hydraulic machine tools, robot manipulators, computer disk heads. The traditional approaches to minimize the effect of residual vibrations are focused either to a significant increase of the structure stiffness, or to the application of feedback control methods.

An alternative approach is the proper conditioning of the pre-specified excitation pattern (Guidance), so that the system moves exactly to the desired end position without any residual vibrations. This concept is very attractive, since it can significantly simplify the requirements of the motion equipment. However, the practical application of these methods has been quite limited, since even small variations of the system properties -due either to the poor modeling of the system or to changes of system variables during operation (e.g. machine payload)- cause significant deviations from the desired response and thus result to significant residual vibrations. The robust performance of the desired guidance function has derived limited attention.

This paper establishes a general framework for preconditioning the desired guidance function by convolving it with an arbitrary ARMA model. The necessary conditions for the robust behavior of the ARMA model are first derived. Then, a general design approach is proposed, according to which the robustness properties cover now, not only local areas of variation around system natural frequencies, but the widest possible area for frequency variation.

Several design methods are then considered, concerning the selection of the parameters both of the full ARMA model and of the reduced AR model. A systematic comparison is then performed, covering the already existing methods and the several methods, proposed in this paper. Special emphasis is devoted in the possibilities of achieving the minimum possible duration time of the ARMA model, while maintaining pre-specified error limits.

Numerical experiments verify the effectiveness of the robustness, not only with respect to variations of the linear dynamic system parameters -such as eigenfrequency and damping ratio- but also with respect to variations of a range of non-linear coefficients, such as the drag force coefficient, the dead-band zone area, and the non-linear spring coefficient.

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Modular robotics design — System integration of a robot for disabled people

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Abstract:
Robotic manipulators are in most cases designed with a specific manipulative application process in mind. In cases of general purpose robots the design of the robot is such that the manipulator can produce motions in as large workspace as possible. However, there is always a cost associated with increased flexibility and this restricts most robots to have six degree of motions where three belongs to the wrist and the other three to the main part of the manipulator.

If the manipulator is used in unstructured environment, such as assisting technology, other demands may be added besides the normal manipulation provided by traditional robot arms, such as mechanical redundancies to move around obstacles or singularity free motions in specific areas in the workspace. Other aspects relates to work places which demand a relatively unique robot configuration.

In order to solve the problem of configurable manipulators a modular approach have been adopted which allow robot manipulators to be assembled from modules into any viable configuration needed for a specific task. In this paper the concept of modularity will be addressed which solves specific problems in robotics design: (1) integrated links with integrated motors, transmissions, motion controllers and power electronics and (2) kinematic models of the manipulator which can be generated for any kind of configuration. Each link is design to have its own controller which communicates with the host computer via a CAN bus network. Thus, a typical robot configuration consists of 3-5 CAN nodes (one node can control more than one link) and the only cables needed for control is a two wire CAN-bus connection and a two wire power supply for the power electronics. All motors are 3-phase brush-less DC. The local micro-controllers in the arm allow for distributed joint level control and easy real-time update of controller parameters.

Integration of the modular links to form a complete robotic arm for use by disabled users will be discussed and shown in the full paper. Results will be provided based on experiments related to technical functions and specifications. Implications and expected results with respect to functionality for disabled people will be discussed.

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Development of an Application Platform for Mobile Robots

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Abstract

This paper describes an Application Platform for the development and testing of mobile robot units. Within this platform, various applications addressing different aspects of mobile robot development are composed into an experimental environment.
The design and development of a mobile robot is a quite complex task that requires the co-operation of a multidisciplinary team of skilled developers. To qualify all members of the development team to an adequate level as well as to provide a sophisticated testing and training environment, within the European Research Project "Mobile Robotics Technology for Health Care Services Research Network – MobiNet" an Application Platform has been specified.
The following techniques have been identified to enable a general purpose mobile robotic platform:

- actuator components as drives and drive control units, handling and gripping devices, finally signal emissions systems (optical and acoustical)
- sensoric components like navigation and manoeuvring systems including perception, collision avoidance and obstacle bypassing technology
- human interaction devices like ergonomic user interaction devices as handles, joy-sticks, folding and unfolding systems for house to house / house to car or house to environment movement and man machine communication interfaces.
- supervisory and maintenance functions as emergency recovering (battery loading), order receiving and diagnostic communication system, error message and emergency handling.

For an efficient and cost minimising strategy, the utilisation of existing industrial robot technology was envisaged.
The basic concept of the Application Platform comprises several generic interfaces to the platform. These interfaces are depicted in figure 1. The Platform Processor provides fully integration of all components.
The area of adaptive functions comprises three elements: Task based sensoric elements, navigation based elements and communication elements.
Operation tasked based sensoric elements are sensors like e.g., tactile, optical or megnetoresistive sensors. Navigation based elements are sensors like radar, laser, gyroscope, 3-D ultrasonic range measurement sensors optics or GPS (Global Positioning System). The

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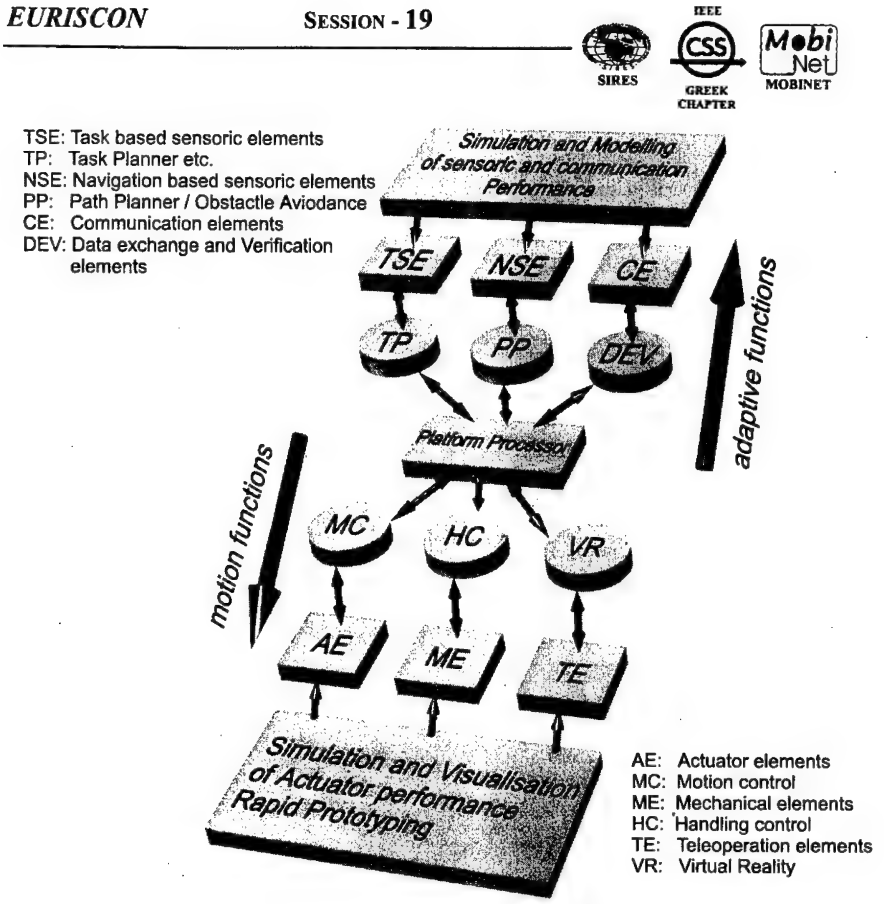

Figure 1: *Basic modular concept of an Application Platform for mobile robots*

communication elements are devices like Etherlink microwave or radiotransmission connections. For the signal processing to the platform processor, each element has a dedicated operation system in front, like a task planner or obstacle avoidance for the task based sensoric or a path planner for the navigation elements. All necessary functions have to be implemented here. The functions itself are determined by the desired task.

Overall these functions is an simulation and modelling environment for determination and validation of the elements to be used in the Application Platform. For this task existing or self-developed software can be applied.

On the other side there are the motion functions. This functions will also comprise several elements: actuator elements, mechanical elements and teleoperation elements.

Parts of the actuator elements are devices like driving wheels, legs or caterpillar tracks. The mechanical element can comprise devices like grippers or servo tools. For the teleoperation elements devices like switchboards, joysticks or user interfaces or even throughout these elements a big range of hardware can be used.

A Framework for the Integration of Perception and Localisation Systems over Mobile Platforms

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Our research team of the UPM-DISAM laboratory is dedicated to the Mobile Robotics technology. A lot of studies have already been realised by the team, especially concerning planning and control requests. Our preoccupation now is to provide an adequate information of the environment to the previous modules allowing them to make right decisions. The planning module asks for a good modelisation of the environment and the control module wants an updated sensor information. To provide that relevant information, we are working on the design of a perception module, based on the incoming information from five heterogeneous perception systems: odometry, sonars, active vision, color vision and navigation laser.

The goal of the perception module is threefold: localisation, map building and virtual perception, although along this paper we will focus in the localisation issue. A good estimation of the position of the robot allows, first, to refine the information comparing it to a modelisation of the robot. Then, it permits to integrate the information to our previous knowledge of the environment. To ensure the localisation of our Mobile Robot, we are using three methods, each one based on a kind of information coming from the sensors. An initial estimation of the position is given by a dead reckoning method, in our case odometry. But that kind of information tends to accumulate its uncertainty along the time. That problem is solved by a first method that realises a matching between the information coming from the sonars and a modelisation of that type of sensors. With a second method, the same kind of matching is realised with the navigation laser. A third method makes use of land marks and the active vision system. All of these localisation methods are based on the matching of observed and predicted information and a recursive integration (i.e. a extended Kalman filter is used). Finally, the results of the three methods are combined to estimate the position of the robot.

The main advantage of such a localisation system lies in its abilities to integrate heterogeneous sensor information and to be configurable depending on the knowledge of the environment encountered. With an environment free of unknown obstacles, the sonars and laser methods will give the best results. But if there are a lot of unknown obstacles the land marks method will be the most efficient method.

However, the purpose of that architecture is not just to estimate the position of the robot. Its matching and its integration of the information provide a sorting out of the information intended to the next two steps of the perception module that are virtual perception and map building. The virtual perception issue makes use of the integrated information to provide a refined information to the control module. The map building issue exploits the information rejected by the matching to update the knowledge about the environment.

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Robot path Planning Using Models of Fluid Mechanics

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Abstract

Several attempts have been made using Laplace's equations (electric field in a conducting plate having insulated islands [1], stress field in materials having cavities [2]) for finding safe paths of mobile robots in an environment cluttered with obstacles. However, the corresponding methods generally lead to long computing times and are limited to flat surfaces. The method presented in this paper aims at computing sets of robust solutions for more general problems including the unevenness of the terrain with respect both to elevation and to friction between vehicle and ground. It is based upon an analogue with the flow of incompressible viscous fluids. The various stream lines obtained by the computation of the velocity vectors of the fluid particles are sorted in order to obtain the "best" (in a certain sense) feasible paths for the vehicle, or vehicles if several of them are considered

Using the steady-state solutions of Navier-Stokes equations not only avoids local minima often encountered in most potential field methods, but also allows one to include a viscosity coefficient. The velocity of a viscous fluid progressively tends to zero when approaching obstacles. Furthermore, the velocity is also zero in regions similar to blind alleys, provided that they contain no sink (goal) point. Finally, when there exists no feasible path, the velocity is zero everywhere. Simulations presented in this paper confirm these properties.

One also takes advantage of the robustness of the solutions with respect to environmental parameters, and of the multiple path character of the solutions. The latter can be used for planning the motions of several vehicles, while in each family of topologically neighbouring paths, the "best" one is selected following a given performance index: speed, energy economy, safety, etc. However, neighbouring paths exhibit similar qualities, that allows adaptation and reactivity in case of unexpected disturbances: the vehicle then deviates slightly from the nominal route without greatly affecting the performance. In the presence of "hills", the analogy with fluid mechanics also tells if the robot is better to climb or to go round.

Finally, the paper presents an application to path planning on a natural uneven terrain, and compares the method proposed here to a previously developed method [3,4] that calls for genetic algorithm principles.

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Creating Dynamic Mobile Robot Environments from an Intelligent Building

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Currently the vast majority of research undertaken in the domain of mobile robotics is intent on the design, construction and control of fully autonomous systems and these robots tend to rely solely on the information gleaned about the world from their own sensors. However, attempting to achieve a correspondence between observation and perception of physically present objects is a particularly difficult task in the domain of mobile robots, primarily because any delay in actuation, as a consequence of prolonged sensor interpretation, can lead to undesirable behaviour. This paper describes an infrastructure for structuring the environment of semi-autonomous mobile robots within the built environment. The approach supports mobile robot navigation and object identification through a distributed network control system consisting of intelligent nodes embedded within the building. Such networks are currently used for building management services such as fire detection, HVAC, lighting control, producing a new generation of flexible intelligent building. The network provides a dynamic representational model of the environment local to the robot as it traverses the environment. The dynamic model contains the physical description of the environment as well as active objects that the robot could control. The physical model is represented by a 3-dimensional format providing the ability to interact with an object in the environment without initially performing some robot-centric classification techniques utilising some preconceived internal notion of what the object should actually look like, permitting the robot to proceed with the particular task it has been assigned to carry out.

A typical scenario envisaged is that of a robot entering into the area controlled by a particular node on the network, that node providing a model to the robot of its immediate environment, the robot augmenting the data it observes alone with this model, and periodically transmitting this data back to the node. This circumvents the need for the robot to maintain detailed maps of a large building. The building can then supply this updated model to other robots should they enter that area under its control.

To allow the distributed control network to actively support this infrastructure, a multi-agent paradigm is introduced as a technique for reasoning about the data necessary in the provision of services for the safe and efficient navigation of the robot within the building. Co-operation and co-ordination between nodes is necessary in order to provide a smooth transition from one area to another and a distributed control strategy for achieving this is described.

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Design of an Active Arm Support for Assisting Arm Movements

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ABSTRACT: In recent years there is an increasing wish for more independence for people with special needs. However, the number of disabled and elderly people will increase as life expectancy increases. Thus we can expect problems with insufficiently staffed hospitals and residential care for old or disabled people. Through the introduction of more robot technology in healthcare this problem can be reduced. Examples include assisting such people, during eating and other everyday activities, independent work, improve the quality of daily life and reducing the cost of healthcare for individuals with neuro-muscular diseases.

The design of a power assisted orthotic mechanism is intended to assist people with disabilities, either helping with daily living or assisting with recovering function. For example, people with muscle dystrophy, motor neuron disease or tremor may use the active arm support for daily living tasks, where as people who have hemipliga after a stroke may require the robot for rehabilitation therapy. The second group of individuals will use the arm support mechanism with adjustable compliance or damped movement to perform task. To meet the variety of needs, that individuals have when performing arm movement a ranged of control methods must be implemented to consider both the task and the user. Changing the fundamental arm control allows the active arm support (AAS) to accommodate individuals and needs without requiring mechanical modification other than adapting the forearm support cradle.

The Mobile Arm Support is a research machine intended to allow the evaluation of new methods of robot design and control that can assist with arm movements and provide a level of therapeutic intervention for an individual with a neuro muscular disease. The AAS is a light mechanism using electric motors to assist arm movements in a horizontal plane, particularly when in a sitting position. The joint mechanism considered has three degrees of freedom, which can usually provide for the movement of the arm. Each joint is powered by a motor, which relays force to the operator's arm. The distances between the joints are the same proportions as for a human arm. The first prototype of the AAS can be used for first experiments with arm movements and first measurements of characteristic values.

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ENHANCEMENT OF A TELEMANIPULATOR DESIGN WITH A HUMAN ARM MODEL

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ABSTRACT: Although current telemanipulator designs succeed in performing their tasks, they are often accused of being tiring, slow, unable to cope effectively with large time delays and providing only an obscure feeling of the telemanipulated objects. This is an important drawback for applications such as telesurgery and rehabilitative teleoperation. It in part results from the fact that the senses of the human arm, as well as the brain decision tactics, due to their complexity and the ambiguity of models previously available, are either neglected or overly simplified. Currently however, various models have been proposed and experimentally verified. These are either in anthropometric or in neural network or other 'black box' form. Their inputs are either the EMG or the neural input. Measuring devices for both, such as surface and implanted electrodes are available, though still in need of improvement.

The authors have explored various ways to employ such a model in telemanipulation area, some of which result in novel designs. In this paper we show how the knowledge of a model can be used to enhance existing architectures. As such we have modified a scheme previously proposed by Y. Yokokohji and T.Yoshikawa by including a module that predicts the hand movement as a response to the measured / estimated input. This is used to direct the slave along the desired trajectory ahead of the master, by exploiting the propagation time of the neural signal through the muscle. This way the slave precedes by up to 200 msec the master, depending on the sensors and computational speed available. The slave's response is fed back to the master appropriately delayed, so that the master will feel the results of his actions through his arm sensors at the same time they actually take place, exactly as in physical 'by hand' operation. This allows the scheme to tolerate time delays in the communication channel of up to the above limit. The other main aspects of the original teleoperator design are preserved, and the presented theoretical analysis leads to passivity conditions following their line of thought. Finally this approach is compared with a novel scheme specially designed to employ a human model, with results favouring the latter. As a model of the human arm we chose the well-established Stark model. Its mathematical representation was modified to make it suitable for use in our application. Methods to invert it, crucial for estimating the input of the human arm and simulate it, were extensively explored and are here briefly presented.

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EXPLOITING A HUMAN ARM MODEL FOR FAST, INTUITIVE AND TIME-DELAYS-ROBUST TELEMANIPULATION

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ABSTRACT: A literature survey conducted by the authors revealed that in current teleoperator designs the human dynamics, due to the complexity and ambiguity of models previously available, are either neglected or simplified to linear models with system-state independent input. It is however empirically found or just assumed that the system is stable. Currently models are available in both anthropometric as well as neural network or other 'black box' form. Their inputs are either the EMG or the neural input. Measuring devices for both, such as surface and implanted electrodes are available, though still in need of improvement. Possible ways to exploit such an arm model for telemanipulator design explored by the authors and reported elsewhere, are based on the prediction of the hand movement as a response to the measured / estimated input. This is used to either enhance existing designs by simply directing the slave along the desired trajectory ahead of the master or to try novel concepts such as estimating the final desired position and servoing the slave there in a semiautinomous manner. In this work too, we use the predictor output to generate the command to the slave, but we also break up the control loop traditionally closed at the master robot: the master's state is still modified according to feedback from the slave, so that the operator senses the results of his actions, but it is not compared against the predictor output - rather we attempt to close the control loop the human brain, mimicking normal human movements. Our approach was inspired by well established physiological evidence that the brain, rather than controlling the movement on-line, 'programs' the arm with an action plan of a complete movement, which is then executed largely in 'open loop', regulated only by local reflex loops. With our approach the traditional bilateral constraint that the two robots are simultaneously compliant to each other's state is lifted, resulting in a succession of only locally controlled modules and thus simpler control. We argue that teleoperation becomes more intuitive and show that it is faster and allows communication time delays of up to 200 msec. Various local control methods are compared. The Stark model of the human arm was preferred, whose mathematical representation we modified to make it suitable for an engineering application. Inverting algorithms for it are also briefly presented. The proposed method is favourably compared with traditional teleoperation and the other approaches outlined above. Finally, its usefulness in rehabilitation applications is outlined.

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A NEW TECHNIQUE FOR NON-INVASIVE ASSESSMENT OF AORTIC PRESSURE MODULATIONS DURING TREADMILL RUNNING.

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During running the interaction between body movement and cardiac ejection modulates the arterial blood pressure pulse with a beat frequency equal to the difference between heart rate and step rate. Increased fluctuations in the pressure pulse impose an added load on the ejecting ventricle and could compromise ventricular ejection. Beating vanishes when heart rate and step rate are equal where, pressure fluctuations are maximal when ventricular ejection and foot strike are in phase, and minimal when out of phase. The transmitted aortic pressure wave becomes amplified along the arterial tree due to changing arterial properties and wave reflection. Because of the frequency dependece of the transfer function, this amplification thus becomes heart-rate dependent and so varies with degree of exercise at sub-maximal heart rates.

Aim. The aim of this investigation was to quantify the relation between the beating amplitude of the peripheral pulse and the central aortic pulse during running at different speeds (and at different heart rates).

Methods. Peripheral pressure was measured continuously and non-invasively in the finger of 8 volunteer healthy subjects while running on a treadmill using a finger cuff device (Finapres, Ohmeda) with the hand held steady at heart level. This was done to avoid the effect of hand movement *per se* on pressure modulation. Aortic pressure was estimated from the peripheral pressure signal using the non-invasive SphygmoCor system (PWV Medical). This device utilises an on-line computerised mathematical transfer function for the adult human arm developed previously from invasive measurements. Beating amplitude for peripheral (PBA) and aortic (AoBA) pressure were determined as well as pressure amplification of the aortic pulse for speeds of 9,12,15, km/hr. Heart rate values are normalised for maximal heart rates at 18 km/hr.

Results. Table shows mean and standard errors for 8 subjects.

Speed (km/hr)	HR* %	PBA (mmHg)	AoBA (mmHg)	Ratio (PBA/AoBA)	Ratio (PP/AoP)
9	78±3.3	15.5±1.7	7.9±0.6	1.94±0.64	1.87±0.03
12	88±2.6	17.1±1.4	9.6±0.6	1.81±0.18	1.97±0.03
15	96±1.4	21.4±3.9	12.2±2.8	1.87±0.20	2.05±0.04

HR*: % of Heart Rate at 18km/hr; PBA: Peripheral Beat Amplitude; AoBA: Aortic Beat Amplitude; PP: Peripheral Pulse amplitude: AoP: Aortic Pulse amplitude.

Conclusions. A computerised on-line mathematical technique can be used for non-invasive estimation of aortic pressure from the peripheral pulse during running. With increased heart rate, the peripheral pulse can be more than twice the central aortic pulse. The beating seen in the peripheral pulse is also present in the aortic pulse, but with a lower amplitude. Beating and pulse amplitudes are amplified to the same degree. Non-invasive estimation of the central aortic pressure may provide a more accurate assessment of the pressure-related effects of running on cardiac load. This may have important implications for assessment of patients with heart disease using treadmill exercise protocols.

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Application of distributed techniques in a set of tools to climatic sensor signal validation and data analysis: DAMOCIA-VAL and DAMOCIA-EXP

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In order to improve the quality of the horticultural products, it is necessary to introduce the new information technologies into the agricultural sector. Among these efforts, we have developed a decision support system to design new greenhouses structures within the *DAMOCIA* project (*Computer-Aided Design for the Construction of Automated Greenhouses*) financed by the *European Union* within the framework of the ESPRIT *projects (Special Action P7510 PACE*). This work included the development of a tool for modeling the climatic variables inside the greenhouses, based in finite elements. In order to verify the models it was necessary to obtain experimental information about greenhouses behavior. This paper describes the application of new computing techniques in the development of tools for signal validation and data analysis. The readings of the climatic sensors must be validated in order to their later exploitation, ***DAMOCIA-VAL*** (*Data validation tool*) contains twenty four filters with this objective. A database of abnormal behaviors is created in order to find patterns that permit automatic corrections. ***DAMOCIA-EXP*** *(Data Exploitation tool*) facilities the agronomic engineers browsing the validated experimental data; it allows an easy manipulation of a very large volume of data (> 10 Gbytes) and the generation of tables, charts, maps of climatic variables along a day obtained by simulation, etc.

These tools have been implemented using, among others, the following techniques:

- ***Distributed Multiagent Architecture.*** The different functions and operations performed with the data are executed by 'connective independent' modules. Different modules communicate via 'message passing', with specialized request/server subroutines. The different processes are divided in independent phases, managed by a special module (*manager*). This one calls different procedures in an alternative and cumulative way.
- ***Multilevel independent interface.*** The interface is independent of the rest of the application and it can be executed in different platforms. Its main function is the execution of the necessary agents to accomplish the selected operations. It has three different level in basis of the kind of user (*Basic*, *Definition* and *Development*).
- ***Distributed data storage.*** We select a distributed storage in different devices due to the large volume of data, their different application and the retrospective use of the data. The databases consist of a set of autonomous and independent CD-ROMs.

The main results obtained are: a tool set for data and signal analysis easily generalizable to any other application environment; an experimental database composed by three main data collections (sensors, validated and analyzed data); and the direct results of the exploitation tool (statistical analysis, evolution charts, etc.). From the accomplished work, we can concluded the following: the use of an distributed open architecture can make easier the incorporation of new analysis and correction modules, and the use of distributed databases allows the storage of large volumes of data, facilitating its use on simulation.

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Geometric Calibration for a Robotic Driven Single-Head Cone-Beam X-ray System

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Single-head cone-beam X-ray systems consist of: (i) a cone-beam X-ray *source*, (ii) the X-ray *detector* and (iii) the object *manipulator* driven by a pan & tilt type of robotic platform, as shown in figure 1. The detector consists of a fluoroscopic converter screen, a CCD imaging device of high resolution and sensitivity and an optical system that couples the CCD imaging device to the screen. These radiography systems are used for inspection of metallic objects for defects. Digital radiographs are acquired for different poses of the object implemented by the robotic platform and then they are combined to provide a 3D reconstruction of the object volume. Thus any existing defects can be detected and defined in terms of size, shape and location. However, volume reconstruction of a 3D object from a set of its 2D radiographs requires accurate knowledge of the geometric parameters of the radiography system.

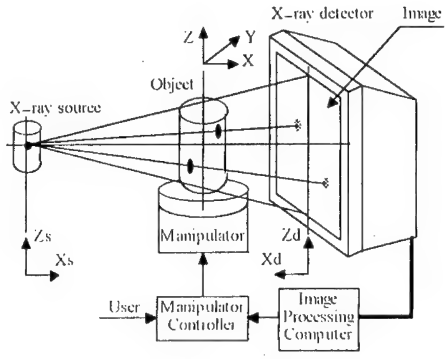

Figure 1. A single-head cone-beam X-ray system.

Geometric *calibration* of a radiography system is the estimation process of its geometric parameters. The geometric parameters can be seperated into *intrinsic*, describing the detection system and *extrinsic*, indicating its position and orientation with respect to the examined object.

We present a method for the geometric calibration of single-head cone-beam X-ray systems. This method can be applied to all possible geometric configurations between the X-ray detection system and the object. The intrinsic parameters are measured only once assuming that the geometry of the detection system does not change between the different acquisitions. The extrinsic parameters are estimated by minimization of a cost function every time the position of the object changes relatively to the X-ray source or the detector. The cost function is the reprojection error measured on reference points of a calibration grid. Powell's zero order minimization algorithm is used to estimate the extrinsic parameters. The choice of the extrinsic parameters initial estimate is critical and thus we apply the fast, non iterative technique of the vanishing lines to provide a good initial estimate without the use of an especially designed calibration object. The vanishing lines method was developed for camera calibration, which is the estimation process of the camera geometric parameters in 3D vision systems.

We performed simulations in order to examine the stability and the accuracy of our extrinsic parameters estimation process. We found that the estimation process is very stable and even with noisy data the estimated values of the extrinsic parameters are centered on those expected.

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APPLICATION OF WAVELET ANALYSIS FOR THE DETECTION OF ELECTROMANETIC FIELD TRANSIENTS OBTAINED FROM MACHINES

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This research paper deals with the detection of on/off events of the electric and magnetic field signatures of various machines. The electric and magnetic field measurements were obtained with electric and magnetic sensors and antennas situated approximately 10m on the other side of a wall from various machines as these machines were activated and shut off. The resulting transient signals are of small amplitude and most of them are buried in the higher frequency noise of the power source and therefore difficult to be detected. For the detection of these transients, the time of their occurrence, their duration and their total numbers multiresolution analysis (MRA) with Daubechies D4 wavelet techniques were used. In this study, several machines were tested (i.e. welding machine, drill press, belt sander, bandsaw and air compressor) with perfect transient degree of delectability. It is important to emphasize here that numerous incidents of disruption (about sixty) in the performance of electronic medical devices by both local and remote sources of electromagnetic energy have been reported. Many of these incidents has or could have had life threatening consequences. The continued occurrence of disruption due to conducted and radiated electromagnetic interference, power-line disturbances, and electrostatic discharge underscores the need for applying electromagnetic compatibility design techniques, standards, and testing to electronic medical devices.

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A Thinning-Based Method for Recognizing and Extracting Peri-Urban Road Networks from SPOT and other Panchromatic Images

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Abstract: The authors have developed a method for recognizing and extracting the road network in peri-urban areas using SPOT panchromatic images. In this paper, we investigate the performance of the method on panchromatic very high spatial resolution air-photos, taking into consideration that the spatial resolution of the expected remotely sensed digital images in the microsatellite era is going to be increased up to one meter.

A particular combination of image representation / description algorithms is proposed, which recognizes road features - not clearly defined in remotely sensed images and often confused with other features - and extracts them. The method consists of five algorithms - thresholding, morphological, thinning, linking, and gap filling - that are used sequentially. The only human intervention required, is the definition of a threshold. The proposed approach produces a raster road network representation that is highly complete and locationally accurate. Some experimental results are given in this paper.

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Digital Image Processing and Integraded Computerised Analysis for Weathering on planning Conservation Interventions on Historic Structures and Architectural Complexes

by A. Moropoulou, M. Koui, Ch. Kourteli, N. Achilleopoulos, F. Zezza

This work regards engineering applications of Image Processing and pattern recognition. The Digital Image Processing on historic architectural surfaces results on the characteristic distribution pattern of the weathering forms, when the microstructural and textural characteristics of weathered stone are used as interpretation criteria.

Image classification to the level of more or less severe alveolar damage, according to IAEG is possible.

The same processing distinguishes compact (new) to disaggregated (old) porous stones and in general restoration materials incompatible to their original ones.

Ultra sound measurements accompanied by Image Processing of the weathered stones (Integrated Computerised Analysis for Weathering) provide insights for the stripped and alveolar decay patterns regarded as laminar or vacuolar calcarenite varieties on monumental samples.

The visualisation of digitally processed images of weathering and building materials permits the allocation of the proper conservation interventions, i.e. conservation planning regarding specifically :

* conservation substitution for old stones by compatible new ones,
* reconstruction and filling of washed out joint mortars by compatible restoration mortars,
* consolidation of disaggregated porous stones due to advanced alveolar disease,
* integration of stone cavities,
* mechanical connection of bearing building stones,
* cleaning of facades,
* finally, valuation of uses and environmental management.

Hence, the combined use of Digital Image Processing, and Integrated Computerised Analysis for Weathering develops a reliable, as far as physicochemical processes of decay are concerned, integrated automatic risk mapping method, regarding the weathering of architectural surfaces and the evaluation of compatible conservation interventions. The coordinated methods should be further searched and standardised in various environments and per various materials, in order to become a tool in the conservation practice.

AN EFFICIENT ALGORITHM FOR RENDERING PARAMETRIC CURVES

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ABSTRACT

Catmull's method is referred as the first successful method for rendering parametric curves. Catmull's idea was that of sub-dividing the space to be rendered until it is reduced to the size of a pixel. This has found extensive use. Later, Blinn, Whitted, Lane and Carpenter presented some scan-line methods for rendering surfaces. The basis of these algorithms was that of finding the intersection of the surface with the plane of horizontal lines, that were processed in a sequential way. Although the convergence to the solution of the intersection was fast enough , one has to deal with stability matters, leading to complicated algorithms, which are difficult to be implemented.

In this paper, a simplified algorithm for rendering parametric curves is presented with extension to rendering (wireframe) parametric surfaces. The basic idea is that of sub-dividing the space with a stopping criterion similar to that of Catmull. The additional feature of the present algorithm is the avoidance of stack use in the recursive rendering and the elimination of some disadvantages of other algorithms, such as the "crack" in scan-line techniques.

The fixed point arithmetic is used for building the binary tree of subdivision since only additions and shifts of integers are required, operations that are elementary and thus very fast. Most of the recursive algorithms used for parametric curve rendering, stop at a subspace where the curve can be well approximated by a linear segment. The stopping criterion employed in this paper works in the image space rather than the parametric curve space. Therefore the subdivision stops when the limits of a subspace correspond to neighbor pixels (along with a 8-connectivity neighborness). In this way, it is guaranteed that the image of the curve will be continuous on screen , without the need to calculate the slope (or some other relevant parameters) of the curve . This leads to simple and effective rendering algorithms with the best possible output results, but with the cost of more parametric computations/evaluations. An important feature of the proposed algorithm is the avoidance of problems like "cracks" (surface rendering) or "stack overflow".

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GRAFCET: METHODOLOGICAL AND FORMAL ISSUES

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Grafcet[11] or function charts for control systems is an international standard[15] used for the specification and the implementation of logic controllers in manufacturing systems. Throughout the twenty years that have passed since it was defined[1], Grafcet is becoming widely used in the industry[5] and in education[16]. The main contribution of Grafcet, which uses a Petri-net like formalism, is that it allows a clear modelling of inputs and outputs and of their relations. It also allows modelling of concurrency and synchronisation. However, and in spite of these advantages, Grafcet has long been criticised because it is not supported by a formal foundation that allows to insure correctness and safety requirements on the one hand, and because it lacks adequate methodology that allows an efficient development of high quality models in the case of complex systems on the other hand.

The objective of the full-length paper is therefore to review the current active research works which have been undertaken recently to overcome these problems. These works attempt to benefit from the recent advances in software engineering[27], in manufacturing-systems engineering[24], in discrete-event systems theory[25], and in formal methods for real-time systems[6, 7]. The paper will be decomposed into four parts (given below), each of which treats one of the current research issues related to Grafcet. The conclusion will present the impact and the significance of the results of these works. It will also emphasise the need to develop an integrated framework to capture the benefits of the works carried out separately alongside each of the four areas. Some directions will be given for the development of such a framework on the basis of meta-modelling techniques[30].

1- Syntactic and semantic extensions to Grafcet

Besides the definition of Macro-steps and forcing orders[28], recent developments have provided hierarchical structure, abstraction levels and reuse facilities to Grafcet[3,13]. These facilities allowed, for example, to extend Grafcet application scope to the control of batch systems. Other extensions of Grafcet[28], aiming to ensure both synchrony, determinism and reactivity of the model, postulate two time scales for Grafcet. An internal one deals with state evolutions and an external one deals with stability. The consistency of this definition has been proved[14] and a theoretical Grafcet player[18] is proposed to accompany these extensions and to organise their interactions with the basic evolution rules of Grafcet.

2- Development methodologies

This section provides a review and a comparison of the main features and the application scope of methodologies that provide a framework for the development of Grafcet starting from a high level description of the manufacturing system. Three of these methodologies[9, 21, 32] are functional based, and two methodologies[29, 33] are object-oriented based.

3- Verification and validation of Grafcet

Active research work has been carried out recently to establish formal support for the verification (of internal consistency) and the validation (of safety, liveness and timeliness properties) of Grafcet. Most of the proposed approaches are limited to the verification and the validation of the behaviour of Grafcet on its own without considering the controlled process. These approaches are based on the use of synchronous languages[2, 19], time automata[20], Petri nets[4], (Max, +) algebra[23], or state machines[26]. Two other approaches are used to validate Grafcet together with the process it controls. The first one[12, 31] is based on an extension of the TTM/RRTL framework[22], and the second one[17] is based on the use of the TCCS/TML framework[8].

4- Synthesis of Grafcet

Two approaches use the supervisory control theory[25] as a support for the synthesis of a supremal Grafcet that represents the minimal possible restriction of the behaviour of a given Grafcet, in a way to satisfy the given safety and liveness requirements. The first approach[10], which has been successfully applied to a real size industrial system, can only handle a sub-class of Grafcet in which the parallel, synchronous and reactive nature of the model are not addressed. The other approach[34, 35] takes into account all the features of Grafcet. These two approaches will be presented and the conceptual and semantic problems encountered in the synthesis procedure of Grafcet will be particularly emphasised.

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TELEWORKPLACE IN LASERMATERIAL PROCESSING

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In the early nineties further components for an effective manufacturing process were developed e.g. in data processing, in telecommunications, and in modifications of computerised numerical controls. To combine that for material processing it would be possible to reduce cost-extensive parts in the field of engineering. Concerning this Laser material processing is a manufacturing method that includes short time cycles on the one hand and high cost operations on the other hand in industrial applications. Therefore Laser technology can be able to use teleworkplace strategies in an excellent way. The project shows first results of our department of mechanical engineering in co-operation with small and medium-size businesses.

The Situation

Meanwhile Laser machining systems are widespread in industry. A lot of enterprises have been investigated with regard to use of teleworkplace technologies. The result shows that the advantages could not fully scoop out up to now. Most of the suggested solutions are based on a discontinued flow of information. In our opinion there are a lot of reasons for that: often the interfaces are not exactly adapted between the several modules, furthermore, the industrial users underestimate the cost-performance ratio of such a solution. Therefore we have started to create a continued project consisting of a modular concept that is capable of development dependent on the special interests of medium-size businesses. By use the manufacture can be completely controlled and monitored by teleworkplace of engineering centre.

The Project Structure

As a first step the file generation function of workpiece a special CAD software is used supporting DXF files.
The second step contains the data transformation of DXF files into CNC files of machine tool with the help of technological set-up parameters.
Thirdly a special data simulation program is able to locate and to remove any errors in-time before the CNC program gets access to the machine tool.
In the fourth module external data file transmission mode is working via Internet to send CNC files from teleworkplace to machine tool.
The fifth step represents the control of manufacture at machine tool and the online-multimedia quality monitoring of workpiece.
The sixth module is a data change module installed for changing data in a.m.steps.
Further steps will offer digital acquisition of orders and pre cost calculation as well as post cost calculation of manufacture.

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Integration of the Predictive Maintenance in Manufacturing System

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Nowadays maintenance is considered as a key point for the manufacturing system competitiveness because first its cost represents the major part of the operational cost, and second, a system failure can have an important impact on product quality, equipment availability, environment, and operator.
One solution to decrease the cost of scheduled maintenance and to increase the manufacturing system dependability and availability is to manage continuously all maintenance activities and to control the failure and the degradation to move to predictive maintenance.
However in the current maintenance systems, the predictive maintenance functions are broken up into several sub-functions supported by separated Information Technology systems without a real organisation and consistency in their implementation strategies.
To face this dis-integration, the Maintenance activity has to be considered as one Enterprise Domain at the shop floor level integrated with the Control and Technical Management ones : the integrated Control, Maintenance and technical Management System (C.M.M.S.).
This integration needs a modelling framework based on reference models to support the required engineering process.
Nevertheless, the function and information Maintenance conventional Reference Models (IMMM, IMDS, IMIS, IDS, CIPO, GAMA, VOICE) are mainly focused on the maintenance management and not on an operating maintenance such as predictive one.
Moreover, in a manufacturing complex system, the whole of the relations between, on the one hand, the system and its environment and, on the other hand, the components of this system, constraints the maintenance system modelling.
Therefore, the aim of this paper is to present our Maintenance Framework based on reference models proposed by international maintenance societies, and improved to support CMMS and predictive maintenance specific requirements.
Indeed, this framework integrates, first, a reference model of transactional information flows formalising the communication between Control and Maintenance domains, and second, an information-based repository to capture the information of each domain and to ensure the consistency of the shared information between Control and Maintenance.
The use of this framework on a grip system of a milling machine tool will allow to demonstrate the efficiency and the interest of our approach to implement an integrated Maintenance System in a manufacturing context.

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THE LATEST DEVELOPMENTS IN AUTOMATED VISUAL INSPECTION OF WOOD BOARDS

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ABSTRACT

Automated Visual Inspection (AVI) is gaining increased interest for the quality control of products. It allows an improvement in the accuracy and consistency of grading when compared to human graders. The applications of AVI systems include the electronic industry, food industry, metal removal industry, textile industry and automobile industry. AVI is currently being applied to the wood industry, where wood boards are sorted into quality categories based on an assessment of their surface appearance. However, this task has the difficulty that wood is a natural material and so every board is unique. Also, some defects, such as sound knots, do not differ significantly from clear wood. Some success has been achieved in this area but much effort still needs to be made to improve the process. Typically, AVI for wood boards is subdivided into the areas of image acquisition, image enhancement, image segmentation, feature extraction, classification and grading. First, an image of the board is acquired by employing a camera and appropriate lighting techniques. Second, the image can be enhanced to make it more suitable for segmentation. Third, the board is segmented into clear wood and defective areas. Fourth, features are extracted from all the defective areas. Fifth, each defective area is classified based on the extracted features. Finally, the board is assigned a grade based on the types of the defects found. This paper reports the latest developments in the area which include modular segmentation, artificial-intelligence-based techniques for post-processing segmented images, methods for selecting the optimum features and synergistic classification systems. The importance of artificial intelligence (AI) techniques in current research is highlighted by the paper. The AI techniques of fuzzy logic and neural networks have all been utilised recently for AVI of wood boards. The neural networks employed have been the Multi-Layer Perceptron, the Kohonen Self-Organising Feature Map and Adaptive Resonance Theory.

Keywords: Automated Visual Inspection, wood, image segmentation, feature extraction, classification.

Automated Visual Quality Inspection of Printed Ceramic Dishes

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Extended Abstract .- In this paper, a first approach to the design and implementation of an automated quality control system of printed ceramic dishes using machine vision techniques is presented. Three main problems are of interest in this task: a) Locating the dish image on the camera frame, b) Determining the rotation angle of the object with respect to a global axis set (orientation estimation), and c) Comparing the test dish image with a non-defective reference pattern, in order to determine its quality level.

An *iterative radius-vector* algorithm has been presented to locate the dish image on the camera frame. The method is based on the coordinate averaging of certain points on the piece boundary. The algorithm is very fast, though its application is limited to elliptic or circular shapes. This is not really a strong restriction since most of industrial made ceramic dishes have these shapes. The algorithm needs the knowledge of a point inside the piece (typically the gravity centre point of the binary edge image), and iteratively approximates the position of the image geometric centre (intersection point of the piece boundary symmetry axis). Just three or four iterations are usually needed to locate the piece accurately.

Orientation is determined through the position of certain templates (extracted from the reference pattern) inside the image to be inspected. The solution adopted is then a template matching approach, using the cross-correlation coefficient as similarity measure between images. A two stage template matching algorithm and some rotationally invariant parameters are used to speed up the process, as well as a few refinements to increase robustness.

Once the piece is properly located and oriented, next step is comparing the two images (reference and test images) in order to perform classification in two classes: defective and non-defective pieces. This comparison must allow slight differences between images, such as small relative deformations or subtle scale variations, while more severe image distortions must be taken as a defect. To build adequate representation of the images to be compared, we use a percentage of the low frequency components in the Fourier domain. These components usually hold information related to general shapes in the images (valuable information in the comparison task we want to achieve), while detail information is held in high spatial frequencies.

The classification task is performed by using a two hidden layered Perceptron Neural Network. The input layer receives a real vector formed with the magnitude of a percentage of the low frequency components. The output layer consists of just one neuron which gives a binary value (0 or 1) that classifies the pattern.

Network training strategies are also described, as well as theoretical aspects related to the use of this kind of neural networks in the classification task we propose.

In order to achieve acceptable execution times, the implementation of all these algorithms has been carried out on a parallel architecture of DSPs C40 processors. Experiments were made to test the classification power of the system using real ceramic dishes of several degrees of complexity. Execution times of less than 3.5 seconds per dish and percentage of correctly classified dishes over 91% have been obtained.

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Knowledge Based Process Monitoring in Mass Production

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Abstract

Especially in highly productive mass production it is essential to maintain the quality of the workpieces and the up-time of the machines on the highest level possible. On the other hand the quality check of each part in mass production, with up to 300 workpieces per minute, is too expensive and time consuming. Consequently the control of the product quality in form of random checks very often indicates quality problems too late. Thus the part rejection rate and losses can reach a disturbing level. Furthermore it is very important to protect the machine and the products against damages caused by tool break. It is therefore a matter of high priority to determine the optimal point and time for an exchange of tools when they have reached the end of their life-span.
To increase the service quality of the machine and to reduce the tooling costs which includes the machine, workpiece, fixture and the tool it is essential to monitor the behaviour of the tools themselves with respect to the tool wear. The systems applied must have a short reaction time and a high selectivity to insure the monitoring of the tool wear and the tool break at the same time. They must be able to react immediately whenever the tool breaks and they must have the capability to detect all other causes of process deteriorations such as tool wear, misalignment of the workpiece or missing coolant.
In order to enable online process monitoring in mass production and to assure quality and productivity a monitoring system is being developed to sense and process typical data generated during the machining of the workpieces, e.g. force, torque, power consumption or acoustic emission which correspond with the quality of the workpiece. This allows the detection of process deteriorations such as tool wear, tool breakage or break down of coolant supply.
In this paper the set-up of a process monitoring system is described which enables the monitoring of drilling and tapping operations with cycle times of less then one second. Special attention is given to the selection of sensors and their performance with respect to the extraction of data to characterise the individual process and to detect process deteriorations. Based on data gained by monitoring and evaluation of different processes in mass production a knowledged base was established. Thus, a fuzzy based monitoring system was developed which enables the detection of different process abnormalities. According to the status of the process messages are generated and displayed, e.g., to initiate the exchange of tools. Typical process signals and results are shown and discussed.

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Conveyor-Belt Diagnostic System Using Time-Frequency Analysis

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ABSTRACT: A conveyor-belt diagnostic system applied for a steel works has been studied. To carry coal, ore and other materials, large-scale conveyor-belt systems work in steel industries. Since representative in-service troubles, such as 'slip' and 'meander', result in a fatal disaster to the system, those accidents must be detected in early stage. But it is very difficult to carry out the plant monitoring by operators because large number of conveyor-belts are distributed over a vast outdoor field. Therefore, it is urgently necessary to develop an automatic monitoring for the detection of trouble.

In this study, an automatic and centralized diagnostic system of the conveyor-belt is developed. Since the driving electric current of an induction motor includes important information on serious conveyor-belt troubles, the current is measured continuously and abnormal fluctuations in it are detected by this system. The system is composed of two sub-systems.

In pre-conditioning system, the current data are roughly separated to two categories of normal and abnormal condition. Then the data selected as abnormal are sent to a time-frequency analysis system in which such analyses as Wavelet transform, Wigner distribution and/or Short Time Fourier transform,STFT, are applied.

In the second stage system, signals are carefully distinguished among 'slip', 'meander' and other normal phenomena. Based on the detail analysis of abnormal condition signals, the following diagnostic-algorithm is constructed: If an anomalous current data satisfies the condition (1), the data is inferred as 'slip' signal. If not, assumed to be 'meander'.

$$s(n) \geq 122[A] \quad \text{and} \quad s(n) > s(n-1) \qquad (1)$$

where n is the discrete representation of time,t. From the basic analysis, it becomes clear that 'meander' can be detected by the analysis of a certain frequency range of signal. Then to find out the trouble, Wavelet transform is applied for the specified frequency band ranging from 0.0025Hz to 0.0050Hz. With respect to this frequency range, instantaneous energy,E(t), is obtained from the integration of $P^2(f,t)$, where P(f,t) denotes a Wavelet coefficient of the signal. An analysis of the distribution of E(t) makes it possible to distinguish between 'meander' and noise signals. Noise signals are rejected by the application of a medium filter. As 'slip' signal is inferred from the analysis of a certain time range of signal, an anomalous signal is processed by Wigner distribution or STFT to detect this trouble. When an optimum window length is specified for the analysis of either method, a 'slip' signal can be clearly extracted every time window. In case 0.8sec is set as the window length, it takes only within 0.5sec to process an anomalous signal and to judge whether the result is 'slip' or not.

It is concluded that this system is very effective to an on-line real-time diagnosis of conveyor-belt operations in steel industries, by applying three different time-frequency analysis properly.

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A framework for realistic integration of Computer-based Manufacturing Systems

by

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Abstract

This work outlines a data definition and manipulation framework for achieving 'minimum' integration among computer-based applications that support the functions of a manufacturing system in all six areas : design, process planning, production planning, production scheduling and control, materials control, and quality assurance. The framework is based on a set of reference interaction models describing the data exchange among these areas both in terms of content and in terms of routing.

The reference nature of data is transformed into actual terms by customised 'translators' depending on the particulars of the actual software systems used, following, however, pre-defined templates. Templates form part of the Integration map, the rest of it being the Navigation part describing how data sources and destinations whether computerised or not should be connected to each other. The Reference Integration Manager controls data flow, formulates queries from and composes answers to individual applications and streamlines interactions by implementing the interaction models. Data Management offers concurrency control and is based on relational schemas both several local ones and a global one. This is supplemented by a global man-machine interface. A particular network implementation is intended with no loss of generality. The paper then focuses on an initial prototype of the interaction models.

The reference data tables have been implemented on the Paradox database management system with sample data coming from a bicycle making business. A number of queries were formulated within each activity according to simple scenarios and the answers were synthesised to provide an overall answer to each scenario.

Initial relational models constructed, but still not validated, demonstrated the complexity of the situation through both volume of data and potential complexity of the data exchange scenarios (transactions).

The work is intended to ultimately produce the following deliverables :

Specification of requirements for minimal interaction models of CIM sub-systems for integration.

Overall minimal integration reference architecture.

A general methodology to achieve minimal integration, based on an Integration Map.
Software tools supporting the integration methodology.

KNOWLEDGE-BASED CONTROL SYNTHESIS OF DISCRETE EVENT DYNAMIC SYSTEMS

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ABSTRACT: An approach to dealing with the problem of the control synthesis for discrete event dynamic systems (DEDS) is presented in this paper. It simultaneously utilizes both the analytical model of the system to be controlled and the knowledge representation expressing the control task specifications (like criteria, constraints, etc.) by means of a knowledge base (KB) in analytical terms. Both the model and the KB are created by means of an analogy with corresponding kinds of Petri nets (PN) and oriented graphs (OG). As to the occurrence there are distinguished two principal kinds of the discrete events here: 1) the spontaneous discrete events (their occurrence cannot be influenced from the outside - e.g. some specific singularities or some unforseen failures); 2) the events which can be influenced from the outside - i.e. 'controllable' events. The problem of the DEDS control synthesis is that of finding the most suitable sequence of the later ones which will be able to transfer the system in question from an initial state into a desirable terminal one or into a desirable terminal set. PN-based approach to creating the system model yields the linear discrete k-invariant system (where k is the discrete step of the system dynamics development) suitable especially for expressing the controllable discrete events. The OG-based approach to modellling is suitable especially for expressing the spontaneous discrete events and yields the linear discrete k-variant system. When PN are understood here to be OG with two kinds of nodes (positions and transitions) and two kinds of edges (oriented arcs emerging from the positions and entering the transitions on one hand and oriented arcs emerging from the transitions and entering the positions on the other hand), the hybrid model of the system is derived by means of combinig both of the previous approaches. In such a model the spontaneous discrete events are expressed by means of the system parameters. The same (or very analogical) approaches are used also for knowledge representation and the analytical models of the KB are expressed in the form of the PN-based (the linear k-invariant logical or/and fuzzy system), OG-based (the linear k-variant logical or/and fuzzy system, especially suitable for expressing the rules in the form of both-sided implications), and hybrid (combining the previous two ones) models.

The approach will be illustrated on an example of flexible manufacturing systems (FMS) and transport systems.

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Min–Max Control with Application to Discrete Event Dynamical Systems

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ABSTRACT: Large classes of dynamic phenomena such as material flow in manufacturing systems, traffic flow in transportation or communication networks, and related scheduling problems can be viewed as discrete event dynamical systems (DEDS); see [1] for a survey. An efficient approach [2, 4] to model large classes of DEDS has been based on the minimax algebra [3] and describes the time dynamics of such DEDS by using nonlinear state space equations which algebraically resemble the linear (sum-product) equations of linear control but in which the addition and multiplication have been replaced by maximum and addition, respectively.

In this paper we propose the following general algebraic model for such nonlinear state-space equations of which special cases are the examples and applications studied in [2, 4]:

$$\begin{aligned} x(k+1) &= \left(A \boxed{\vee} x(k)\right) \vee \left(B \boxed{\vee} u(k)\right) \\ y(k) &= \left(C \boxed{\vee} x(k)\right) \vee \left(D \boxed{\vee} u(k)\right) \end{aligned} \tag{1}$$

where $\vee$ denotes pointwise maximum (or supremum), $\boxed{\vee}$ is a max-sum matrix 'product' defined later, $x = (x_1, x_2, ..., x_n)^T$ is a n-dim state vector with $x_i(k)$ representing the start-up or completion time of the k-th cycle of machine i, u is a r-dim input or control vector representing availability times of parts, y is a m-dim output vector representing exit times, and the elements of the (constant or time-varying) matrices A, B, C, D represent service/delay times or activity durations. The components of the vector x, of the vectors or scalars u, y and of the matrices $A \in \overline{\mathbb{R}}_{n\times n}$, $B \in \overline{\mathbb{R}}_{n\times r}$, $C \in \overline{\mathbb{R}}_{m\times n}$ and $D \in \overline{\mathbb{R}}_{m\times r}$ are from $\overline{\mathbb{R}} = \mathbb{R} \cup \{-\infty, \infty\}$. The *max-sum matrix 'product'* $\boxed{\vee}$ of a $m \times n$ matrix $A = [a_{ij}]$ with a $n \times p$ matrix $B = [b_{ij}]$ is the $m \times p$ matrix $C = [c_{ij}]$ defined as

$$C = A \boxed{\vee} B \quad , \quad c_{ij} = \bigvee_{k=1}^{n} a_{ik} + b_{kj} \tag{2}$$

with $a + (-\infty) = -\infty$ for any $a \in \overline{\mathbb{R}}$.

A *dual* algebraic model for control is also obtained by replacing in (1) maximum ($\vee$) with minimum ($\wedge$) and the max-sum ($\boxed{\vee}$) with a min-sum matrix product ($\boxed{\wedge}$):

$$\begin{aligned} x(k+1) &= \left(A \boxed{\wedge} x(k)\right) \wedge \left(B \boxed{\wedge} u(k)\right) \\ y(k) &= \left(C \boxed{\wedge} x(k)\right) \wedge \left(D \boxed{\wedge} u(k)\right) \end{aligned} \tag{3}$$

where the *min-sum matrix 'product'* $\boxed{\wedge}$ of a $m \times n$ matrix $A = [a_{ij}]$ with a $n \times p$ matrix $B = [b_{ij}]$ is the $m \times p$ matrix $C = [c_{ij}]$ defined as

$$C = A \boxed{\wedge} B \quad , \quad c_{ij} = \bigwedge_{k=1}^{n} a_{ik} +' b_{kj} \tag{4}$$

with $+'$ being regular addition extended by the rule $a +' (\infty) = \infty$ for any $a \in \overline{\mathbb{R}}$.

The nonlinear state equations of (1) (or of (3) can also model the dynamics of nonlinear discrete-time filters described by the max-sum (or min-sum) difference equation [6]

$$y(k) = \left(\bigvee_{i=1}^{n} a_i + y(k-i) \right) \vee \left(\bigvee_{j=0}^{p} b_j + u(k-j) \right) \tag{5}$$

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capable of modeling a large class of morphological systems used in nonlinear signal processing and image analysis [5, 6, 7]. Specifically, setting $x_1(k) = y(k-n)$, $x_2(k) = y(k-n+1)$, ..., $x_n(k) = y(k-1)$ and choosing the matrices A, B, C, D appropriately in terms of the coefficients a_i and b_j models (5) as a special case of (1).

In this paper we view the nonlinear state-space equations (1) and (3) as describing a large class of nonlinear dynamical systems whose system-theoretic and control aspects we call **min–max control**. This paper deals with the theory of min-max control and its application to DEDS. Our new contributions include the following:

- Derivation of the complete solution of (1) and (3) in the discrete time domain and decomposition of this solution into a zero-state and a zero-input response, where by 'zero' we mean signals equal to $-\infty$ or $+\infty$.
- Description of the system's zero-state response in terms of nonlinear convolutions (of the morphological type) of the input signal with an appropriately defined impulse response of the system.
- Study of stability.
- Study of observability and controlability by developing algebraic criteria based on matrix rank as defined in minimax algebra.
- Study of min-max feedback.

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Learning processes and logic-algebraic method in knowledge-based control systems

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ABSTRACT

The paper concerns a class of knowledge-based control systems with a static plant described by a logical knowledge representation. For such a system the logic-algebraic method has been developed. The main idea of this method consists in replacing individual reasoning concepts based on inference rules by unified algebraic procedures based on the rules in two-value logic algebra. The results may be considered as a unification and generalisation of the different reasoning procedures.

The purpose of this paper is to present the methods and algorithms of learning in the control system with unknown parameters in the knowledge representation. The learning consists here in step by step knowledge validation and updating, and current using the results for the correction of the control decisions. The different versions of this general concept are described and investigated: the learning in open-loop and in closed-loop control systems. The simple numerical examples with the determined form of the knowledge representation and uncertain parameters are given. The results of computer simulations for the different versions and algorithms of the knowledge validation and updating in the control system are presented. The purpose of the simulations was to investigate the influence of the fixed system parameters on the convergence of the learning processes and on the final results of the learning. In particular, the interesting results have been obtained for the case when the knowledge-based control is reduced to the knowledge-based pattern recognition with learning.

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Static Output Feedback Stabilization: An Application to a Class of Distributed Parameter Systems

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Abstract

Since the first contribution by Davison [1] was published, the problem of pole assignment by a costant gain output feedback has received considerable attention ([1, 2], [4, 8]) because of its importance in both theoretical and pratical aspects. In [2], Kimura derived a simple condition for pole assignability, which says that if $m + p > n$, then almost all complex numbers are assignable as closed-loop poles; there n, m and p are the numbers of state variables, inputs and outputs, respectively.

An alternative formulation of this problem has been proposed of the same authors [9], where the right eigenvectors of the open-loop dynamic matrix are chosen as a basis of the state space.

In this note we shall illustrate an application of the results shown in [9] to a distributed parameter system (DSP) of parabolic type.

The purpose is to present a solution of a pole allocation problem using static output feedback, such that all the closed-loop eigenvalues are in a region on the left of $\Re(\sigma)$, where $\sigma \in \mathcal{C}^-$.

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RECENT RESULTS ON ANALYSIS PROBLEMS FOR UNCERTAIN CONTROL SYSTEMS

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In the present paper some recent results are presented, that face analysis problems for control systems that suffer from uncertainty. These results concern the stability robustness of certain classes of linear and nonlinear systems.

The first method presented derives sufficient conditions for robust stability of uncertain matrices whose elements are multivariable polynomials of- the uncertain parameters. This method suggests the use of a new parameterization of uncertainty that turns the presentation of uncertainty in a multilinear form. Then the robust stability of the uncertain matrix can be established by testing the stability for a finite number of matrices corresponding to extreme values of the new parameters of uncertainty. The contribution of this method consists in the reduction of the required number of tests in comparison to other similar methods. In this way, the chances to achieve satisfaction of the sufficient conditions generally increase.

Next, a small gain theorem for locally input-to-state stable nonlinear feedback interconnected systems is presented. The application of this theorem can derive under certain assumptions the bounded input-bounded state stability for interconnections that fail to satisfy other small gain theorems. The criterion that has to be satisfied by the gain functions is quite general, since it is applicable even for gain functions that are not bounded by any linear function in a neighborhood of zero. This theorem can be used in order to study the stability robustness of systems with unmodelled dynamics.

Finally, the stability of the closed-loop system produced by the application of a feedback linearizing control law to a feedback linearizable system with unmodelled dynamics is studied. The study is based on the application of a small gain theorem, which is also established for nonlinear locally input-to-output stable feedback interconnected systems. More specifically, sufficient conditions for the system's stability robustness are derived. The satisfaction of these conditions can be easily tested.

Numerical examples are included that support the applicability and effectiveness of the three methods.

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Robust Time-Optimal Control with Nonlinear PD Compensators

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In control design, linear and nonlinear compensators are considered, the latter showing improved capabilities for a wide class of linear and nonlinear dynamic systems. The design procedures for nonlinear compensators are mostly based on heuristic rules, while in many cases the procedures based on linearization methods, describing function methods etc., becomes a tedious task.

An alternative method which gives very satisfactory results is proposed in this paper, and is based on the time simulation of the controlled system and on a novel parameter optimization method.

Based on the above, a nonlinear compensator is proposed which yields time optimal and robust capabilities. The structure of the compensator is a second order Taylor-series function approximation with proportional and derivative terms. Optimum parameters of the compensator are determined, using also a novel semi-stochastic optimization method, based on Box's complex technique.

Finally an illustrative example referring to the time optimal control of an active suspension system with u- ù limits demonstrates the effectivity and performance of the proposed procedure.

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CONTROL OF AN AUTOMATON USING UNCERTAIN INFORMATION

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Abstract: The control of well-modelled continuous or discrete systems has been greatly studied in the past and many algorithms are now available to solve various real–time control problems. In the case of complex systems, it is very difficult to obtain by identification methods, any models accurate enough to be used for efficient control. For some kinds of control objectives, it is sometimes easier to consider these systems automata. In spite of this conceptual simplification, it is often necessary to deal with uncertain on their functioning and this infers problems of modelling and control of automata.

The understanding and utilisation of the Speech Recognition technology allow to augur, in the next future, a wide establishment of vocal control systems in the production units. The vocal interface introduces a new problem of the control of a deterministic automaton using uncertain information. We have now two predictive systems. One model takes information about the past and present state of the system and makes a prediction of its state in the near future. The human – machine interface provides orders taken about information from the past and the present state of the surrounding environment. We have the essential elements of an Anticipatory System (figure) which forms an expectation of future events and renders a decision accordingly. A large part of this paper is devoted to the problem control of a deterministic automaton using, on the one hand, stochastic information of its Pattern Recognition Module, and on the other, fuzzy information provide by the Speech Processing Module.

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MODEL-BASED ESTIMATION OF TIME-VARYING PARAMETERS AND STATE VARIABLES IN AEROBIC BIOPROCESSES

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The application of modern model based control algorithms in bioprocesses is hampered by the lack of accurate and cheap on-line sensors. The design of state observers, which reconstruct states out of a limited set of measurements, is a possible approach for dealing with the measurement problem. Due to the time-varying behaviour of the biological systems, the measurement problem can only be attacked properly by designing adaptive observers, i.e. algorithms estimating simultaneously immeasurable state variables and unknown time-varying parameters. At present, two methodologies are proposed for simultaneously estimation of state variables and time-varying parameters (reaction rates, specific reaction rates and yield coefficients). One of them, proposed by [1], is based on on-line measurements of at least one state variable, while in the other, [2], it is assumed that some yield coefficients and reaction rates are on-line measured.

In this paper, a new approach for estimation of time-varying parameters (biomass growth rate, specific growth rate and yield coefficient for oxygen consumption) and immeasurable state variables (biomass concentration) is presented for a class of aerobic bioprocesses using only on-line measurements of the oxygen uptake rate. The approach consists in the design of a new parameter estimator of biomass growth rate and yield coefficient for oxygen consumption on the basis of theory of adaptive estimation. The dynamical equation of the measurable reaction rate, oxygen uptake rate, is presented as a linear one with respect to the biomass growth rate and to an auxiliary parameter, functionally connected with the biomass growth rate and the yield coefficient for oxygen consumption. In this way, the structure of the proposed estimator becomes linear time-varying one. After some mathematical transformations, that structure is presented in a form, allowing to be derived the stability conditions using some theoretical results concerning the the stability of adaptive observers. The estimates of the biomass concentration and specific growth rate are obtained on the basis of the generated estimates by the estimator using well known kinetic models of bioprocesses.

The dynamical behaviour of the proposed estimator is illustrated on simulation data, generated by using process models, which belong to the investigated class of processes. The performance of the estimator (convergence domain and noise sensitivity) as well as its robustness against both parametric and structural uncertainty are studied.

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Highly Accurate Pipe Length Measurement Using High Order Modes of Stationary Wave

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ABSTRACT : Stationary waves are immediately formed in straight pipes when an acoustic pressure is added. The authors previously proposed an on-line measurement system of the pipe length by modeling the stationary waves as an output of a linear dynamic system. Adequate candidates were given to the pipe length and a bank of Kalman filters were applied to each of the dynamic models. Using the estimated values from the Kalman filters, the posteriori probabilities of the candidates were then calculated and the measurement of the pipe length was achieved. Though the method realized an on-line measurement of the pipe length with a few observation data, it still needed to select optimal values of variances of the observation and system noises on a trial and error.

In order to avoid the trouble of choosing the variances, the authors subsequently proposed a generalized on-line measurement system which estimates automatically the unknown variances. In this method, candidates having to be given for the three unknown parameters (pipe length and variances of observation and system noises), the method gave rise to a problem of increased calculation load. The authors therefore considered to give efficient candidates and to apply the Powell method to accelerate the measurements. The results showed that the rate of the measurement error was 0.15∼0.35% with the observation data of a very short interval of 0.2 sec. In this method, however, stationary waves up to the third mode were used, considering the fact that the stationary waves of high frequencies tend to disappear faster than those of lower frequencies.

It was understood, thereafter, in the experiment that not only the lower modes of the stationary wave but also higher modes are often contained in the fluctuation of acoustic pressure. Having higher frequencies compared to the lower modes, the higher modes are seen to improve the measurement accuracy when estimating the pipe length using the acoustic fluctuation.

This report thus proposes a highly accurate measurement system using high order modes of stationary wave contained in the acoustic pressure. The procedure is as follows : First, the measurement of the pipe length is achieved using the low order modes model. Based on the measurement, the optimal high order modes are next selected through a criterion. With the optimal high order modes model, the pipe length measurement is done once more with the same procedure as in the low order modes one. Lastly, an experiment shows that the proposed method gives a highly accurate measurement of the pipe length of the error rate of 0.01∼0.08%.

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Automation and Optimization of the Can-Filling Process of Fish

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Abstract

This paper will describe an innovative, automated system for portioning and filling fish into cans in an optimal manner. The paper will describe the stages of post-filling and filling. A method will be described for optimizing the portioning process so as to obtain a desired target weight, with minimized overfilling and underfilling. A suitable control system will be presented for the automated system.

Salmon canning is an important industry in North America. In Canada and USA, for example, about 100 million kilograms of salmon are packed every year. Accurate portion control during the canning process takes an important significance particularly in view of steadily increasing production costs and declining fish stocks. Specifically, overfilling of cans will represent a loss of revenue. An underfilled can may have to be inspected and "patched" at an additional cost, for if ignored, it may result in both consumer dissatisfaction and violation of regulatory requirements. Accurate portion control is difficult with the existing machinery in a conventional fish processing plant. Consider a typical portioning process. Fish are "cannery dressed" first by removing their heads using an iron butcher machine, and then further cleaning by gutting and trimming the tail and the fins. Cannery dressed fish are subsequently fed into a cutter unit consisting of gang knives. Two to four workers are needed to feed fish into a cutter unit. The blades of the cutter unit are equally spaced. Consequently, the cut width of the fish portions is fixed. The fish portions are mechanically transmitted through a twister tunnel and forced into the filler pockets of a rotary-turret filler unit. A tumbler fork mechanism assists in pushing fish portions into a filler pocket. Each pocket has a movable half, which closes while the fish portions are forced in by the tumbler fork mechanism, thereby forming the desired cylindrical shape for can filling. Excessive meat is forced out of the pocket during this forming process, and trimmed off by means of a rotary knife. Empty cans are fed at another end of the filler table and are conveyed under a filled pocket. Salt is placed in the can and the cylindrical portion of fish is pressed into the can in synchronism by means of a cam-driven plunger.

It is clear that what has been described is a volumetric filling operation; there is no guarantee that the target weight for a can is met to a required tolerance. About three workers monitor these operations of cutting and filling. The filled cans are conveyed to

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an inspection/repair table. Here, four to five workers who stand on the two sides of the table, look for poorly filled cans, with respect to the aesthetic quality as well as weight. Adjustments are made to the poorly filled cans, manually, at this station. Filled and inspected cans are then ready for placement of the lid.

It is clear that volumetric filling is the primary reason for underfilling and overfilling errors in the canning process. In order to overcome this problem, a more flexible and automated system for can filing is being developed in the Industrial Automation Laboratory at the University of British Columbia. This system incorporates automatic grouping of fish, optimal cutting, can filling, and post-filling inspection and correction, under the supervision and control of an intelligent, hierarchical control system. In the pre-filling system, the cannery dressed fish are placed on a conveyor and scanned to measure their geometric characteristics. Their weight characteristics are estimated on this basis. The fish are overlapped by a mechanical device, according an optimality criterion, based on their weight distribution, and are cut into approximately fixed-weight portions using a knife unit whose blade spacing can be adjusted by means of a computer-controlled mechanism, according an optimality criterion. An objective of optimal overlapping may be considered as making the average weight distribution equal to the target weight distribution. In the general case, the parameters of optimization are the level of fish overlap and the cut width (or, blade spacing). If the blade spacing is fixed, only the overlap parameters may be used in the optimization process. The optimization problem includes several constraints; for example, tolerance on target weight and the can height.

For this proposed system to be feasible, several key components have to be developed. First, a method for fast, on-line measurement/estimation of the weight distribution of a cannery dressed fish has to be developed. A criterion for determining the degree of overlap between adjacent fish and also the blade spacing, for realizing optimization of the portion weight with respect to the target weight has to be developed. Also, devices have to be designed and developed for mechanical control of the degree of overlap of fish and the blade spacing of the cutter. Some work has been completed in overlap optimization. In this paper, we will concentrate on the features of the overall automated system, and the associated intelligent control system.

LONGITUDINAL ELASTICITY MODULUS OF SINTERED POWDER TEST PIECES

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ABSTRACT: The test pieces of sintered powders, with height in logarithmic scale, were strained at longitudinal vibrations. It was established the linkage relation between the vibration and density, respectively between vibration and transversal section, used the conclusions regarding the vibrations in compact metallic material. Using the test pieces of compact material, someone can realise the methodology to compute the longitudinal elasticity modulus regarding the compact material, and in this way it can be established the expression for longitudinal elasticity modulus with application to test pieces of sintered powders.

Theretical Considerations.

Longitudinal elasticity modulus, E, is a material specific feature, which, in general, is established on test pieces, by longitudinal stress. This procedure, is possible to apply to compact material but not to sintered powder parts (or test pieces).

For sintered parts the establishing of Young's modulus, in this paper, it is proposed the determination of the longitudinal elasticity modulus by transmition of mechanical vibrations to test pieces of sintered powders..

The longitudinal vibrations tests were performed on dimensional groups of test pieces of sintered powders, the average values of the longitudinal modulus of elasticity are 3.6769×10^9 N / m^2 .

Conclusions about Testing of Test Pieces of Sintered Powders.

Regarding the experimental results in my work the conclusions are:

1. Longitudinal elasticity modulus of sintered powders is two order of magnitude smaller then the longitudinal elasticity modulus of compact material (steel).

2. The longitudinal modulus of elasticity has the tendency of increasing with height, h , if the other two dimensions , L and l , are maintained constant.

3. Elasticity modulus increasing as the density increases.

4. The cumulated determination error is 2×10^7 N / m^2 ($2 \times 10^{-2} \times$ E) for adopted method (2% of E).

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Ionic Polymer-Metal Composites (IPMC) As Biomimetic Sensors and Actuators-Artificial Muscles

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ABSTRACT

This paper discusses a number of recent findings in connection with ion-exchange polymer-noble metal composites (IPMC) as biomimetic sensors and actuators. These smart composites exhibit characteristics of both actuators and sensors. Strips of these composites can undergo large bending and flapping displacement if an electric field is imposed across their thickness. Thus, in this sense they are large motion actuators. Conversely by bending the composite strip, either quasi-statically or dynamically, a voltage is produced across the thickness of the strip between the two conducting electrodes attached. Thus, they are also large motion sensors. The output voltage can be calibrated for a standard size sensor and correlated to the applied loads or stresses. They can be manufactured and cut in any size and shape and in particular in the form of micro sensors and micro actuators for MEMS applications. In this paper first the sensing capability of these materials is reported. The preliminary results shows the existence of a linear relationship between the output voltage and the imposed displacement for almost all cases. Furthermore, the ability of these ionic polymer-metal composites as large motion actuators and robotic manipulators is presented. Several muscle configurations are constructed to demonstrate the capabilities of these IPMC actuators. This paper further identifies key parameters involving the vibrational and resonance characteristics of sensors and actuators made with IPMC's. When the applied signal frequency is varied, so does the displacement up to a point where large deformations are observed at a critical frequency called resonant frequency where maximum deformation is observed. Beyond which the actuator response is diminished. A data acquisition system was used to measure the parameters involved and record the results in real time basis. Furthermore, reported in this paper are load characterization of such active polymer composites made with a noble metal such as platinum. The results showed that these actuators exhibit good force to weight characteristics in the presence of low applied voltages. Finally, reported are the cryogenic properties of these muscles for possible use by NASA in a harsh outer space environment of few Torrs and temperatures of the order of -140 degrees Celsius. These muscles are shown to work quite well in such harsh cryogenics environment and thus present a great potential as sensors and actuators that can operate at cryogenic temperatures.

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RELIABILITY ANALYSIS OF POWER TRANSMISSION NETWORKS USING THE ENVIRONMENT OF GEOGRAPHICAL INFORMATION SYSTEMS

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ABSTRACT: In recent years, considerable interest has been shown in applying advanced computer facilities and tools for achieving efficient power system planning and control. The objective of this paper is to present a new efficient computational methodology which has been developed for graphically managing the power transmission network topology and data using the computational environment of a Geographical Information System (GIS). An input procedure was developed for representing the network topology by using either existing network plans or creating new system structures. The representation of network structure within the graphical environment of the GIS has been achieved by using a programming code which was developed applying the GIS fourth generation programming software. This technique results in the convenient handling of network topology with quick and easy management of databases. Efficient RDBMS techniques are combined with other previously developed programming techniques in order to model the transmission network characteristics. A reliability modelling and evaluation technique for composite generation and transmission systems using the Monte Carlo simulation approach was also incorporated into the developed methodology. This technique was efficiently implemented in Fortran powerstation 4 and Visual basic 5 programming languages. Finally, the analysis of a power system based on the Greek interconnected transmission network is presented and the obtained results for various case studies are discussed.

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EFFECTS OF SUPPLY WAVEFORM ON HIGH POWER VARIABLE SPEED SQUIRREL CAGE INDUCTION MOTORS

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Variable Speed Drives(VSD's) employing squirrel cage Induction Motors(IM's) and inverters(quasi square wave, PWM) are quite common. They are applicable for motors of wide range of capacities having a range of few KW to MW. Although normal inverters can achieve smooth speed control of drives, there are certain special applications like man-made fiber industry which requires that the inverter should have fuse co-ordination so as to protect the motor without shutting the inverter, which is possible with Pulse Width Modulated(PWM) inverter.

It has been observed elsewhere that the 6-step Voltage Source Inverter(VSI) with constant Volts/Hertz control results in additional harmonic losses, undesirable harmonic(pulsating & steady) torque's and consequent temperature rise of the machine which calls for 10 - 20% derating of the capacity of the motor in case of 6-step VSI supply. Further, it is established in the same study that the drive in addition to the above disadvantages the VSI drive suffers from reduced efficiency and noisy operation. The only advantage in the above application is that the fabrication of the inverter is commercially feasible even for induction motors of large capacities.

The purpose of the present paper is to bring out the performance of a high power variable speed squirrel cage induction motor controlled by (I) 6-step VSI supply, (ii) Sinusoidal PWM inverter supply. The procedure adopted for the steady-state performance evaluation is to (a) simulate digitally 6-step VSI and sinusoidal PWM supply patterns, (b) analyze the simulated non-sinusoidal waveforms of (a) and , (c) finally to compare the performance of the machine with VSI and SPWM operation using the conventional perphase equivalent circuit under constant Volts/hertz.

The specific contribution of this paper is the performance analysis of the high power variable speed squirrel cage induction motor in the frequency domain using the per phase equivalent circuit, which has a provision for incorporating variation in the rotor bar resistance and reactance at different frequencies of operation. Various performance characteristics of squirrel cage induction motor(MW range) are generated at different frequencies with 6-step VSI and sinusoidal supplies at constant V/f operation. A comparison of losses obtained in this study is made with the loss model for inverter supplied induction motors. In this study, it is observed that very large capacity induction motors of MW range have very high inherent maximum efficiencies due to large frame sizes adopted, consequently the losses hardly exceed 4 - 5%. In this way the design feature of over sizing the frame of induction motor results in very high over all drive efficiencies.

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COMPUTATION METHODS IN SIMULATION OF THE DIELECTRIC BEHAVIOR OF NON UNIFORMLY POLLUTED INSULATORS

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Abstract

This paper deals with the dielectric behaviour of non-uniformly polluted insulators by means of a mathematical procedure based upon well known models, a model developed by the authors of the paper and using available own experimental data. The surface of the insulator is considered to be non-uniformly contaminated, since the pollution layer is treated to follow different functions of distribution.

The distribution of the pollution layer is determined according to two methods:
i) the insulator is divided into two major parts, each one considered to be uniformly contaminated and
ii) the pollution layer of the insulator is considered to be distributed across the creepage distance according to a mathematical function.

Thereafter, the critical voltage of the insulator is calculated under the specified distribution of the pollution, by means of the above mentioned procedure and using only the geometric dimensions of the insulator, the arc constants and the pollution severity.

In this paper is presented the dependence of the critical voltage upon the distribution of the pollution layer and the total deposit on the insulator. Furthermore, a curve fitting procedure is developed in order to determine a simple analytical correlation between the critical voltage and the distribution of the pollution layer as well as the total deposit of the insulator. Diagrams show the variation of the coefficients of the curve fitting formulae upon basic insulator characteristics.

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SOME CONSIDERATION CONCERNING THE ERRORS INDUCED BY IMPEDANCE MEASURING ELEMENTS IN CASE OF ELECTRIC POWER SYSTEMS

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ABSTRACT: In this paper, some consideration concerning the errors induced by impedance measuring elements in case of distance protection for electric lines are presented. The real position form of the actuating characteristic is determined and compared to the ideal situation defined in case of using low sensitivity threshold elements.

The shape design of the actuating characteristic of the impedance measuring elements requires computations in which current $\underline{I}$ and voltage $\underline{U}$ in the fault loop are implied.

In paper, the specific case of protections based on absolute values comparison is considered. In fig. 1 the principle protection scheme is presented. It was denoted as FF_1 and FF_2 the function generators, and SE the sensible element.

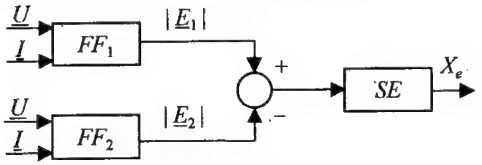

Fig. 1. The principle protection scheme based on absolute values comparison

The case of a linear function generator and the case of quadratic function generator are considered.

In the presence of unavoidable U_0 insensibility of the measuring element used in distance protection schemes, differences in shape and position between the actual and ideal actuating characteristics exists.

The insensibility of the measuring element has a reduced influence in case of using quadratic functions by comparison with linear functions. When using quadratic functions only their position is modified. A qualitative and quantitative evaluation of the impedance measurement errors could be obtained by introducing an error index that would take into account the actual impedance measured value, v and a, and the actual position in the plane (R, jX) or $(R'/a, jX'/a)$ in rapport an ideal work characteristic.

The study of the extended n–degree functions with a bigger than two degree are not used in practice.

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Adaptive LQ Optimal Autopilots for Tankers Based on Two-Point Multirate Controllers

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ABSTRACT: Linear quadratic control theory can be applied to ships, in order to obtain increased performance when sailing in restricted waters and reduced fuel consumption when sailing in open sea. In particular, the trade-off between accurate steering and economical steering of tankers can be easily related to a quadratic criterion. In this respect, in the present paper, we propose a new adaptive LQ optimal autoipilot for tankers described by Nomoto's 2nd-order model, which is a third order unstable single-input, single-output linear state-space model. The proposed adaptive LQ optimal autoipilot is based on a new class of multirate controllers, called Two-Point-Multirate Controllers. In such a type of controllers, the control is constrained to a certain piecewise constant signal, while the controlled plant output is detected many times over a fundamental sampling period T_0 and its multirate sampled-data over a sampling interval are appropriately used for feedback. The indirect adaptive control strategy suggested in the paper, relies on solving the continuous LQ regulation problem and estimates the unknown plant parameters (and hence the parameters of the desired multirate controller) on-line, from sequential data of the inputs and the outputs of the controlled plant, which are recursively updated within the time limit imposed by the fundamental sampling period T_0. On the basis on this strategy, the original problem is reduced to an associate discrete-time LQ regulation problem for the performance index with cross product terms, for which a fictitious static state feedback controller is needed to be computed. Thus, the present technique essentially resort to the computation of simple gain controllers rather than to the computation of state observers, as compared to known techniques. As a consequence, the exogenous dynamics introduced in the control loop is of low order. The proposed adaptive scheme is readily applicable to non-minimum phase tanker models, and to models which do not possess the parity interlacing property (namely, they are not strongly stabilizable). Persistency of excitation of the controlled system is assured without making any assumption on the existence of special convex sets in which the estimated system parameters belong, or on the coprimeness of the polynomials describing the ARMA model, as in known techniques. The a priori knowledge, needed to implement the proposed adaptive algorithm, is controllability and observability of the continuous and the discretized system under control and its order. Simulations results for several tanker models, clearly illustrate the efficiency of the proposed adaptive algorithm which has a quite acceptable performance.

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A PRACTICAL APPROACH TO MOTION CONTROL FOR VARYING INERTIA SYSTEMS.

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ABSTRACT

The trends of intensification in the machines productivity such as the highest operational speed, minimising the time consuming, increasing of the effective loads, accuracy, efficiency and reliability are characterised the modern machinery. To satisfy these quite contradictory requirements may only if the complex analysis of movements in the machinery with consideration of all essential dynamic situations is applied.

Control of the axis drives in multi-axis machines also requires precise co-ordination. Such devices operate at high speed, which places significant demands on the control system. These requirements, at the lowest level, demand precision control of position and speed of the individual axes. Performance is generally dictated by the limitations of conventional control techniques, which sometimes cannot meet the high accuracy demands within economic and technically feasible constraints.

During the last decade integration of mechanical systems and electronics has opened new possibilities for system design and automation. As the performance of servo drives continues to improve, high-speed motion control is becoming essential for flexibility and agility of manufacturing systems. It is well-known, from previously conducted research that it is not sufficient to use merely static terms for dynamic modelling and control, since varying inertia can be a significant factor. A directly driven four bar linkage mechanism frequently exhibits cyclic variation in load inertia at the servo-drive and very often these cyclic variations dominate the system dynamics.

Frequently, applications exist where a linkage is directly coupled to the motor. The advantages of this approach are higher velocity ratio, minimal friction and reduced backlash. However the directly driven systems are subject to a varying inertial load due to changes in the linkages configuration. Such systems are typically employed in packing, sewing and handling industries.

The results obtained from both extensive simulation and test-rig implementation prove that the proposed approach significantly improves the servo system performance. In this paper a practical approach, based on the energy transfer, to identify the inertia-dependant parameters in a high-speed servo system has been considered and illustrative examples have been discussed.

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Robust Feedforward Control Design for Variation of Resonant Frequency and Its Application to Crane Systems

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Abstract

In the high-speed mechanical transfer systems, inappropriate command inputs generate the vibration of the plant, and make the control performance worse. It is therefore extremely important to study the command inputs, namely feedforward control without the residual vibration. From the practical point of view, guaranteeing the robustness in feedworward control will be essential because feedback-loop is not implemented. To our knowledge, there is few studies concerning robust feedforward control under the consideration of optimality.

This paper discusses a method for robust feedforward control against the perturbation of resonant frequency concerning the single-degree of freedom system. Algorithm of robust feedforward control is proposed here for linear time-invariant systems. Proposed robust control inputs is represented by higher-power series of time than the analytical solution designed for the nominal model. Many coefficients of control input are determined by coefficient comparison of n-th power on time (n=0,1,...) to be satisfied the boundary condition at the initial time and the end time, and the remaining coefficients related with robustness are determined by DFP method to be minimized the following performance index:

$$J = \int_{\omega_0}^{\omega_1} W(\omega)(\theta^2(T,\omega) + \frac{1}{\omega^2}\dot{\theta}^2(T,\omega))d\omega$$

where $\theta(T,\omega)$ is the vibration at the end of acceleration for the system with the resonant frequency ω , $W(\omega)$ is a weighted function for the frequency ω, and ω_0 and ω_1 are respectively lower and upper bound values in the perturbation range of resonant frequency. Performance index J evaluates the square of the amplitude of the residual vibration in the phase plane, and the minimization of J means to progress the performance in the total sense against the mismatch between the resonant frequency used in nominal control design and the actual one in the practical processes. The usefulness of the robust feedforward control proposed in this paper has been demonstrated by simulations and experiments of the overhead traveling crane systems for the various constant length of rope.

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Tracking control for Automated Bridge Cranes

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Bridge cranes as large area covering robots require a control, which guarantees a high tracking accuracy. That means, the deviation between a reference track and the actual track has to be minimized. Therefore a control concept is developed, which achieves this goal by four main steps: a decentral control structure, parameter dependent state space controllers, compensation of the nonlinear process behavior by estimating the disturbances, and parameterdependent pilot controls. The decentral control structure is characterized by decoupling the dynamic model of the crane. Thus, each axis has its assigned part of the model, which is not dependent on the dynamics of the other axes.
In the paper, as a example, for one axis, the following procedure of the control design is presented. At first the mechatronic model of the crane axis has to be identified by frequency and time responses. Special measurements to evaluate the friction concerning the nonlinear process behavior complete the system identification. This results in a linearized state space model of 9th order. The analytical state space controller design leads to parameter dependent control gains. So changing load and length of the rope is considered by changing control gains. Although system parameters vary a constant eigenvalue configuration of the feed back system is guaranteed.
In automatic crane systems the rough operating enviroment as well as the nonlinear dynamic behavior of the system is a major problem. Therefore, an observer for estimating the system disturbances is introduced. After derivation of the disturbance model a parameter dependent reduced observer is designed also. The dedicated feed back of the estimated disturbance is able to compensate the nonlinearities of the process and other upcoming external perturbances. The complete system of controller and observer is optimized in several recursive steps by a multi model stability analysis. To improve the control behavior the position, velocity, acceleration and jerk of the load are used as control inputs. The time dependent functions are generated considering the maximal values of these variables. These variables are weighted in the sense of a parameter dependent pilot control.
The control is applied at a 5-ton- bridge-crane. The paper closes with a detailed discussion of measurements at the crane and a video animation of the 5-tons-bridge crane.

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Batch and adaptive instantaneous blind source separation algorithms applied to pyroelectric sensor responses in real time

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We propose here an application of blind source separation (BSS) for a follow-up in real time. The purpose of our project is the de-noising of an experimental signal which has been emitted by a laser diode. A set of pyroelectric sensors provides us with the measurements of this beam, embedding in noise due to the environment. Due to the sensor sensitivity, it is difficult to get a good noise reference, which makes the traditional techniques of denoising inefficient. Hence, BSS is used to obtain best results. An important thing to keep in mind is that we want to recover the most perfect signals as possible : the decontamination must be done before an on-line treatment of the signal (digital synchronous filtering), this one has to be very precise.

Some previous results have shown the good performances of off-line algorithms (JADE, SOBI). It is necessary to apply this type of algorithm regularly, since sensor signals can change over time. The first technique implemented consists therefore in a set of 1,000 sample batch, with a temporal recovery of 10% in order to permit the correct reconstruction of the signal. Each of them will bring an evaluation of the correct signal with a delay of one batch, nevertheless permitting the wanted in-line treatment. The main inconvenience is that for an abrupt change in sensor signals, the current batch is not meaningful, resulting in a loss of information.

The intervention of an adaptive algorithm should permit us to solve the problem previously described, provided that we obtain a very fast convergence to lose the least possible of meaningful parts. Due to the nature of these algorithms, a fast increase toward the stationary point leads to a fluctuation of the values of the mixture matrix parameters (precision / stability dilemma). In order to get a coherent reconstruction of the signal at any time, these parameters must remain as stable as possible. We suggest to use, on the one hand, an averaging of the parameters and, on the other hand, a decreasing adaptation step coupled with a detection of mixing matrix's change. We therefore test the efficiency of these approaches on our experiment. The simulations carried out take into account the mixture of a sinusoïd with Gaussian noise, which coincides with observations of our real signals following the first obtained results. A change of the mixture matrix during the sampling permits us to represent a discontinuity that can occur for example in the case of a variation of sensor orientation.

The instantaneous model of Heraut and Jutten's neuromimetic algorithm as well as normalized family of EASY adaptive algorithms (SPFS) permit us to obtain encouraging results. However, convergence speed and stability of these adaptive algorithms have to be optimized in a different manner according to the employed method, by a discriminating choice of the adaptation step and non-linear functions.

Results obtained by application of these methods to our experiments are very promising for a follow-up in quasi real time.

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DESIGN OF PART-MACHINE CELLS IN MANUFACTURING SYSTEMS USING MATHEMATICAL PROGRAMMING TECHNIQUES

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Abstract

The successful application of cellular manufacturing, within the framework of Group Technology, is based on the formation of self contained manufacturing cells. The design of such a manufacturing system aims at achieving: i)the grouping of machines into cells, ii)the grouping of parts requiring similar machining operations into part families and iii)the assignment of part families into machine cells so that every part of a part family undergoes (almost) all of its processing in the assigned machine cell. In this paper two mathematical programming approaches are presented.

In the first approach the cell formation problem is modelled as a linear integer programming problem with the objective of minimizing the number of inter-cellular moves subject to cell-size constraints and taking into account the machine operation sequence for each part. Next, families of parts which are to be processed by the corresponding machine cells are identified employing a simple model.

In the second approach a model is proposed which answers *simultaneously* all three of the above mentioned sub-problems of the design phase of an efficient cellular manufacturing system. The problem is formulated as a 0-1 quadratic programming problem.

An interesting feature of the proposed models is that there is no need of specifying *a priori* the number of cells to be used. This is automatically adjusted within the solution procedure. The solution procedure employed is an appropriately adapted version of the Simulated Annealing algorithm. Computational results for random instances of medium sized production systems are presented.

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Static and Dynamic Control of Discrete Event Dynamic Systems

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Abstract - A Discrete Event System (DES) is a dynamic system representing processes for which the evolution of the state is triggered by the occurrence of physical events. Such systems arise in a variety of contexts ranging from flexible manufacturing systems to communication systems at some level of abstraction. The synthesis of a supervisor for a discrete event process requires 1) A model that provides a complete description of the behavior of the process, and 2) A model of the desired or legal behavior. This work investigates such structures from the viewpoint of control theory.

The principal features of discrete event processes in this work is that they are discrete, asynchronous, deterministic and acyclic. Typical instances include flexible industrial systems, communication protocols, trafic control systems e.t.c. The supervisory control theory introduced by Ramadge-Wonham provides a formal framework for their study.

In the general case a DES (plant to be controlled) is modeled as an automaton that generates a formal language over a finite alphabet S whose elements are the automaton's transitions or events. Disablement is made to depend on the past history (string) of generated events, in such a way that a design specification of the controlled system behavior is satisfied. Under suitable conditions the control law can be optimized, in the sense of minimally restricting plant behavior.

According to Ramadge-Wonham framework the uncontrolled plant behavior and the desirable one are given in terms of a strings based generated formal language. In this way the objective is to design a supervisor which by disabling certain controllable events produces a system with a desirable behavior. In this setting various control theoretic ideas have been explored, including controllability, observability, stability, modular control, hierarchical and decentralized control and limited lookahead policies.

It is natural to enhance the abstract automaton model of Ramadge-Wonham by exploiting algebraic regularity of internal system structure when it exists. To design control policies for such systems the desirable controlled system behavior is given in terms of predicates over the state set. In this way after one controllable event's occurrence the supervisor processes information related to the current state in order to decide the enablement or disablement of event.

The supervisors considered in this work are static if the control action is determined by the present system state only else they are dynamic i.e. based on the previous history of the system before it reaches the state. For the dynamic supervisors a memory mechanism must be provided in order to track the event string and based on that control action is determined.

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KNOWLEDGE-BASED SYSTEMS USED TO CONTROL THE ENZYMES BIOSYNTHESIS PROCESSES IN BATCH BIOREACTORS

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ABSTRACT: The paper approaches a theme of primary interest, i.e. the control of a set of biotechnological processes such as the enzymes biosynthesis. A methodology frame is provided to develop knowledge bases for the expert systems used to control enzymes biosynthesis processes. This methodology was validated on an expert system prototype intended to control the biosynthesis of alphaamilase and bacterial protease with the microorganism Bacillus Subtilis; the system was called "BIOEXPERT-1". From the analysis of the rough knowledge, it seems that the knowledge base of an expert system used to control an enzymatic biosynthesis process, must contain the following categories of rules: identification of the microorganism growth stage, diagnosis of the process state, control rules and emergency rules. In order to cope with the uncertainty, which is specific to the enzymes biosynthesis processes, the system employ inexact reasoning based on the certainty factors for evidence and for rules. For this we map the uncertain statement to a CF number between –1 and +1, that represents the degree of belief in the statement. Data acquisition was made from: the human expert in this field (by interviews method), case studies (experimental data collected directly from the bioreactor) and the literature. In order to formalize the knowledge base a knowledge network was used. A rule has the following structure: *RULE*: rule number, *CF*: certainty factor, *PRIO*: priority, *IF*: antecedent*THEN*: conclusion, *DESCRIPTION*: comment. A number of 44 rules from the categories mentioned above has been entered into the rule base of the system (rules for recognizing the microorganism growth stage, rules for diagnosis of the process state, control rules and rules for approaching the abnormal operations). BIOEXPERT-1system was achieved in a joint work with the Food Research Institute from Bucharest. In order to develop the knowledge base of BIOEXPERT-1, a rule editor has been implemented in the system. BIOEXPERT-1 is able to check the syntactic accuracy of the rules and to eliminate redundancy from the rule base. The inference engine is a forward chaining type. BIOEXPERT-1 is a multitasking system that was tested by numerical simulation, using a model of the biotechnological process instead of the process itself. The authors intend to implement this system to BIOFOR-II-AUTOMATIC bioreactor that is to be found at Food Research Institute from Bucharest.

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A tool for the Evaluation of fieldbuses reliability for Intelligence Distributed Automation System design

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ABSTRACT: The design of a Distributed Automation System which includes a fieldbus, requires some knowledge about the reliability of the communication services. In order to achieve this goal, a tool which allows the estimation of the reliability of the missions that a fieldbus has to perform could be helpful in order to compare some solutions and to define the better architecture.

An inventory of the communication system missions allows the designer to put in evidence what kind of failure mode he has to consider; obviously, the potential failure modes depend on the communication protocol. These protocols are classified according to their properties to synchronise the transmissions with data producers or with consumers, or to diffuse periodically and autonomously the data. With a dependability point of view, each of these protocols possesses some advantages and some disadvantages.

The method used to establish an evaluation of the reliability of a network for a considered mission includes the following steps, which lead to a generic fault tree:

1) the definition of the mission. It could be the periodical refresh of a data or the alarm transfer. As far as an alarm is concerned, the mission of non-occurrence of a fault alarm can be considered.
2) the choice of the fieldbus protocol.
3) the fieldbus configuration parameters. It concerns the different periods of each component (writing and reading periods, transfer period of the fieldbus). The number of frames and their length to accomplish a transfer, the capacity to resume after a failure, the number of redundant buses are also used. At final, this will permit to compare several solutions for the configuration.
4) the failure rates. These are the probabilities that a byte is disturbed.

Finally, the presented fault tree is applied via a spreadsheet page. It facilitates the data entering and the evaluation of different solutions.

To conclude, the interests of this tool are on the one hand, the inventory of missions of a network and the corresponding failure mode to which the designer must heed. On the other hand, the possibility of doing an evaluation with the aim to compare various architectures based on dependability gives the designer a means to choose between various material architectures (bus redundancy, type of fieldbus...) and the value of its software parameters.

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The Process Plan Sequence in Welding Steel Structures of Diesel Engines

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The structures of the great diesel engines, which are used in ship propulsion and in thermoelectric plants, are produced by electric welding joint of elementary components worked out from steel sheets by oxygen cutting. There are four functional parts to be produced in welding department: the monobloc column, the bed plate, the air intake manifold and the gas exhaust manifold. The process plan is a set of the following operations: handling and positioning, tack welding, welding and straightening.
Great difficulties arise in the definition and the optimisation of the welding PP: **a)** there are many elementary components (hundreds); **b)** each elementary component is welded to the contiguous one by operations which can in general also be discontinued; **c)** handling and positioning each component depends on its mass and dimensions and it can be forecasted; but if it concerns subassemblies, time and resources depend on the former operations in the PP and can not be known a priori; **d)** in welding process the best position is horizontal, it is to choose between handling subassembly for attaining a better position or accepting a more difficult operation; the answer also depends on the former steps in the PP; **e)** numerous constraints are to be considered as: quality, tolerances, technology, accessibility, the balance. It is still difficult to approach the PP optimisation problem beginning from the graph, which represents all the possible assembling connections, rejecting then all those non compatible with the constraints, because point d) and e) would not be overcome. This approach is actually object of research. In this paper the authors present a first simplified approach to the problem by generating consistent sequences of the operations and the selection of the optimal one. In the first place, the attention is pointed out to the structures here discussed, the architecture of which is characterised by a repetition of geometric modules as many as the cylinders of the engine. This allows a drastic reduction in component number to be treated and the relative mass handling is not difficult. The constraints are given by design specifications which are coded in the drawings. They can be translated in precedence relations between operations requested by the working set of the module. Other constraints and relative precedence relations, concerning the manufacturing system and the technology, should be added by the planner. The planner compiles a detailed list of all the operations to be performed and a list of the before stated precedence, that obviously does not cover all the operations. A precedence matrix or graph is solved and a small number of sequence solutions are expected to be analysed. The selection of the best solution is well accomplished by the help of a relational database, which computes any welding process requested and asks questions to the expert planner about handling and other set up activities.

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RELIABILITY COST ASSESSMENT IN COMPOSITE POWER SYSTEMS USING THE MONTE CARLO SIMULATION APPROACH

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ABSTRACT: The ability of a power system to provide an adequate and secure supply of electrical energy at any point in the time is referred to as the reliability of the system and supply interruptions, regardless of their cause, constitute a reduction in this reliability. An optimal operation plan should achieve minimum operation and damage cost. Both, system operating and customer damage costs depend on system states and on the type of customers at each load bus. Reliability cost / reliability worth assessment of Composite Generation and Transmission System is seriously affected by time of occurrence, duration and frequency of interruptions. Therefore, it is necessary to simulate a considerable number of system contingency states involving various load levels in order to obtain the expected values of these costs. The paper describes a computational technique for evaluating the costs of interruption and, hence, the reliability worth in composite generation and transmission power systems considering the time varying loads and the type of customers at each load bus, in relation with the above factors of interruptions. This technique was developed using the sequential Monte Carlo simulation approach and using the linear programming method for archiving a minimum operating and damage cost for system customers. The basic features in this technique are the recognition of different damage costs at different buses for different customers and the consideration of the duration of system contingencies. The computational method has been implemented efficiently into an interactive computer program which was written in FORTRAN77. Various case studies were conducted using the IEEE Reliability Test System and the obtained results are presented and discussed.

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Perspectives of Implementing Automated and Robotics-based Techniques In Road Infrastructure Construction and Maintenance Operations

By

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Abstract

Transport by Road in Europe is constantly increasing. The preservation therefore of a high quality road network is of paramount importance in the EU. The present network suffers from three major problems: aging; increased demand; and increased truck traffic. At the same time an economic trend for tighter budgets spent for infrastructure is observed. In this aspect new innovative techniques are urgently sought, which will reduce cost without adversely affecting quality of work for the various needed Road Infrastructure Construction and Maintenance (RICM) operations. European Commission, Directorate General VII, Transport has initiated and financed the research project **ART**-*Automated and Robotics-based Techniques- New Solutions for Road Construction and Maintenance* to address the issue of employing such techniques in the corresponding activities associated with preserving an adequately performing European Road Network.

Within the framework of this project the involved organizations determined a specific list of RICM operations in urban and rural areas as the most critical ones taking into account the frequency and budget allocation for these operations. For each of these operations individual tasks were selected on the ground of hazardousness, repetitiveness or tediousness and cost. For these critical tasks of each operation the main and critical functions were firstly identified wherefrom then a *technical scenario* for realizing an implementation of Automated and Robotics-based Techniques resulted. For the various technological components of the technical scenario three classes were used for stating their potential introduction possibilities, i.e. "product" for parts that represent state-of-the-art or limited development work; "development" for items which enough development work is needed; and "research" for these items that represent neither a product or a technique and for which a possible realization requests further supportive research work.

The technical scenarios formed the basis for determining the time horizon and development cost of the necessary ART components: kinematics, gripper system, drive technology, power supply, undercarriage, sensor technology, control, man-machine-interface, and information flow were determined.

From the investigated list of RICM operations the most important one is the paving operation. For this operation a design scheme for introducing and employing ART was carried out from which its performances and benefits in relation to conventional paving techniques are derived.

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Integration of multiple software tools on an user friendly environment for the design and analysis of structures, application to the greenhouse design

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In the Province of Almería, taking advantage of its favorable weather conditions, it is situated the largest concentration of greenhouses in the world. Now, the liberalization of markets threatens these advances, becoming necessary to counterbalance this competition by means of technological advances adapted to our environment. There is, too, a normalization process on Europe, conditioning the financing conditions to the presentation of adequate projects.

In order to obtain a new range of greenhouses adapted to our conditions and facilitate the elaboration of building projects, we detected the existence of software tools fitted to resolve partially the process of design. There were general tools for structural analysis, drawing, and cost evaluation, but no one resolved the full problem, being necessary to manage different descriptions with each tool. Another problem was the fact that the technicians of the constructors were not skilled with these different tools. Our proposal was to elaborate an integrated tool that facilitates the definition of the proposed structures using an user oriented windows interface and integrates some proved tools. The tool (complemented with a simulation tool) allows the definition of customized structures, generating automatically project plans, budgets and structural analysis reports. It manages automatically commercial tools for structural analysis (SAP) and drawing plans (AutoCad, CorelDraw), and integrates a budget generator.

The techniques applied were:

- ***Different level declarative descriptions***. High level definitions describe structures in a compact, user oriented format. Low level definitions describe them using their most basic (and general) elements. The different declarative languages are formalized with BNF grammars.
- ***A two level distributed software architecture***. In the first level the whole process is broken into separate processes, that act, mainly, as translators between the diverse description languages or managers of the integrated commercial (generating the final results). The second level of distribution corresponds with the internal structure of these translators and managers, distributing the treatment of the different elements.

From the accomplished work we can conclude the convenience of integrating proved tools on user friendly environments for structures design and analysis. The use of distributed soft architectures and declarative descriptions facilitates this integration, generating extremely adaptable tools. DAMOCIA-Design is implemented and working effectively for commercial and educational purposes. This work was financed by the UE (P7510 PACE) and the Spanish Ministry of Industry (PATI PC-191).

ON THE CALCULUS OF THE AXISYMMETRICAL SHELLS WITH AXISYMMETRICAL LOADS USING THE TRANSFER-MATRIX METHOD

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ABSTRACT: This paper studies the axisymmetrical shells with axisymmetrical loads using the Transfer-Matrix Method (a computational methode of strain and stress). The study for the shells with constant thickness and uniformly distributed load started from the Jules TACHE (1956) formulas and from the Jean GUILLOT (1989) principle. The approach, consist in discretizing parts into a small number of rings. The software can be integrated in a CAD package. For each ring, the Transfer-Matrix, linking the state vectors of the two ring side is calculeted. Its coefficients are determined in according to Strength of Materials hypotheses. A general expression allowing to determine stress and strain within any side was established with the final formula and a computing software produced. We have developed the programme AXIG, which, by using the geometrical characteristics, the material and loading for all rings (that by the superposition make up the shell), gives the state vectors, the increasing vectors and the stresses and strains for all the surfaces of the rings of the shells. Beginning from the state vector of the "origin side", the side 0, $\{U\}_0$, we can make all the calculus with matrix and vectors, and we arrieved to a linear equations system.

The results obteind with the Transfer-Matrix Method (TMM), for stresses and for deformations, (the calculus code AXIG), were verified with Finite Elements Method-FEM (the calcul code MEF-MOZAIC, the COQX modul with the axisymmetrical linear elements).

The work were conducted in the Mechanical Departement of National Institute for Applied Sciences, Toulouse, France.

EURISCON '98: The Third European Robotics, Intelligent Systems and Control Conference (Athens, Greece, 22-25 June, 1998)

THE APPLICATION OF THE TECHNIQUES OF NUMERICAL IMAGERIE IN THE ANALYSIS OF PHOSPHATED MATERIALS

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Summary

The techniques related to the treatment of phosphates and particularly those related to the determination of the exploitable portion are now beased on two processes : microscope analysis and the determination by analytic methods : chimical, physical and physico-chimical (spectography, X rays, etc.).

We thus identify the existing phases (qualitative analysis) and carry out a certain number of measures (quantitative analysis) such as the size of particls, number of grains, the percentage of existing minerals, etc.

Although providing satisfactory results, the two processes mentioned above are too long To improve the time of execution of the analysis and to geat rid of the subjectivity of the operator, we, in this article, propose a method based on the techniques of numerical imagerie. They are generally well known methods of image treatment which should be adapted to the specifity of the instrument.

The non-destructive method permits a qualitative analysis of the row phosphate sample in thin slides leading to the differentiation of the different existing mineral phases and specially the phosphated portion (multi-model analysis of 7 microscopic images) The latter will be then quantified by using the techniques of reconstitution in R3 in order to obtain the granulometric repartition of the sample.

The necessary steps for this analysis are original in conception for so far no work has been done in the field of phosphate techniques that could be used as a reference.

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Current techniques in Distributed Sensor Networks and connection with AI and GIS

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Abstract

In this paper, an overviewing discussion of current techniques in Distributed Sensor Networks (DSN) is provided giving emphasis mostly to the Global Positioning System (GPS) application (which is one of the most popular applications of DSN), as well as, to the techniques of activity recognition using a forest of stationary sensors. The fundamental concepts and components involved in these systems are also included. In addition, a variety of other applications, using DSN technology enhanced with GPS and Geographical Information Systems (GIS), are briefly discussed. Some of them may profitably be used in the future in everyday life applications. The most interesting applications discussed in this paper are mentioned below:

i) *GPS using satellites as sensors* in laser altimetry applications can accurate calculate X,Y and Z coordinates of any point on the ground in order to create the DTM (Digital Terrain Model). With DTM data one is able to forecast water levels, and model the effects of new buildings, in order to prevent flood damage with building restrictions, and flood control works. In that stage using GIS one can give "meaning" to both spatial and non-spatial aspects of the data, i.e. "where" and "what".

ii) *Video surveillance and Monitoring methods* are used to detect any kind of difference from a spatially distributed set of sensors and any detection of moving objects having the ability to continuously track multiple discrete objects in an cluttered and changing environment. The result in this stage is a tracking system that can track multiple objects in real time, and acquire statistical data about each tracked object. This technology has been experimentally used in traffic control applications where data (such as speed and traffic) are collected by a network of sensors distributed over a large geographic region and used for further analysis for road planning.

iii) Police, fire, emergency medical service units are using GPS receivers to determine the police car, fire truck, or ambulance nearest to an emergency. In nowadays automobile manufacturers are offering moving-map displays guided by GPS receivers as an option on new vehicles.

iv) Possible *future applications* such as perimeter patrol, urban security, primitive detection of moving objects amongst a forest of sensors, classification of primitive moving objects (e.g. people / animals / vehicles) are also mentioned.

The issues discussed in this paper show clearly the increased capabilities of DSN technologies and how useful can be in many sections of everyday life.

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PART 3

SOFTCOM '98 ABSTRACTS

Recent Developments in Neural Network PID Autotuning

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Despite all the recent developments in control algorithms, such as adaptive control, predictive control, etc., still PID controllers are the type of controller most employed in industry. This comes from their simplicity (only 3 terms to tune) and from their robust performance in a wide spectrum of situations. Whether because the plant to be controlled is time-varying or because of components aging, these controllers need to be regularly retuned. Since an accurate tuning is a time-consuming operation, and as even a single plant can have hundreds of these small regulators, methods, which automate the tuning process, are economically important. For this reason, several methods have been proposed in the literature, starting from the initial work of Ziegler and Nichols, back in 1942.

More recently [1], [2], novel approaches, involving the use of artificial neural networks (ANNs), have been proposed in this field. Although two different approaches have been considered, both employ the nonlinear approximation mapping capabilities of ANNs for delivering, on-line, the PID parameters to a standard PID controller. The ANNs are trained off-line, before being employed on-line, to approximate the mappings between identification measures of the plant and the optimal (according to the ITAE criterion) PID values. The two versions differ in the identification measures employed. In [1], the plant transfer function (with unitary DC gain) is evaluated in the real axis, based on integral measures of the output and/or the control signal. As these integral measures can be obtained in closed (PID control) and in open loop, this technique is applicable to both. In [2], the identification measures employed are the critical frequency and the critical gain. As these can only be obtained in closed loop proportional control, this technique is only applicable in this situation.

In the approaches described above, the neural network parameters remain fixed after the off-line training phase. Excellent results have been obtained with both approaches, as long as two conditions are fulfilled:

- the training data adequately spans the input space of the neural networks,
- the actual plant to be controlled lies within the training space.

Current work, which will be described in the paper, addresses on-line adapation of the ANNs, therefore improving the performance of the neural network autotuners as result of on-line tuning experience. It will also address the possibility of considering simultaneously additional tuning criteria, employing for this purpose the well know good properties of multiobjective optimization of genetic algorithms.

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Hybrid Control System consisted of a Neural Network and a conventional controller.

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In this paper a hybrid controller consisted of a Neural Network and a conventional controller will be presented. New learning algorithms will be used to train this controller in order to implement the hybrid controller for repetitive manufacturing processes. Control problem in manufacturing are characterised by deficient knowledge of the whole model and controllers perform their tasks under disturbances and noise. Having in mind these operational conditions for the manufacturing system and our objective, which is the development of appropriate controllers, it is proposed the development of Neural Network Controllers trained using advanced learning algorithms.

The proposed structure of control system is consisted of a conventional PID controller which stabilises the process and an Neural Network is used as a feedforward controller. The input for the Neural Network is the output of the process and the output of the Neural Network is the control signal to the process. In this way the Neural Network is coping from the PID controller which train the Neural Network, furthermore Neural Network is trained to emulate the desired controller by interpolating the input-commands pairs of the desired controller in real time.

For this Neural Network a new learning algorithm is proposed which is characterised by adaptive learning rate which has excellent results when the available information is inadequate. This algorithm belongs to the family of successive over relaxation algorithms and he adjust the learning rate for every weight of the Neural Network utilising information from the error function and the Jacobian function.

This algorithm calculate the next element of the weight series $\{\mathbf{w}_k\}_{k=0}^{\infty}$ solving the following equation for each component of the weight vector

$$E\left(w_{k+1}^1,\ldots,w_{k+1}^{i-1},w,w_k^{i+1},\ldots,w_k^q\right)-E\left(w_{k+1}^1,\ldots,w_{k+1}^{i-1},w_k^i,w_k^{i+1},\ldots,w_k^q\right)=0. \quad (1)$$

This algorithm adjust the local learning rate for each weight of the Neural Network and so at every repetition it creates the direction where it is looking for the minimum.

The proposed structure of controller with this new learning algorithm for the Neural Network has excellent results for repetitive manufacturing processes that will presented at the Symposium.

Acknowledgement

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IMPLEMENTATION ON OF N-STEP AHEAD NEUROCONTROL IN ENGINEERING APPLICATIONS

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An N-Step-Ahead neurocontrol method called Chain-Back-Propagation (CBP) is presented. It is based on the well-known Truck-Backer-Upper example, however properly extended and enhanced to be applied in complex, highly non-linear and realistic dynamic equations of motion. The basic neural network (NN) structure of the CBP method is formed by enhanced Back-propagation NN. Contrary to most existing methods, the system is considered as completely unknown (i.e. Black-Box), any need for models being satisfied with the use of neural emulators. In trajectory following applications, instead of using a reference orbit, the training takes place on a range of set-points that cover a significant range of the joint or the Cartesian space. In this way, the controller is allowed to make full benefit of the available potential of the system.

Since the CBP is a reinforcement-training-based method, no "teacher" controller or training pattern set is needed. In cases of non-linear multi-DOF systems, a crude or bad quality controller may be used as the initial controller NN. In all cases, the method renders the final controller better than the initial one, exploiting the system potential more efficiently. Special emphasis is given in constructing the appropriate penalty function, that controls the training procedure of the controller, using criteria that take into account the whole orbit that the system follows in time. The Credit Assignment Problem, quite critical for the operation of the method, is solved both in Emulation Mode and in Real-Time Mode. Qualitative criteria like Final Error and Final Error Rate, Overshoot and Rise Time may be used, making the method clear and understandable. The training of the CBP method is further assisted by local-in-time penalty terms and simple transformations that secure the convergence of the controller.

The CBP method is demonstrated in two applications: A) a 2-axes articulated manipulator operating in the vertical plane under the effects of gravity and B) a 3-axes real-world complex hydraulic Cartesian manipulator. Both systems are highly non-linear and their axes of motion are strongly coupled. The results of the CBP method are compared to those of hard-limited conventional and extended PD control and to those of traditional one-step-ahead neurocontrol, concerning the accuracy the speed and the overall efficiency. The charts and suitable performance indices used, clearly show the superiority of the CBP method. The training time for the controller was in the range of 1~3 hours for the 3-axes hydraulic manipulator.

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Adaptive self-tuning neural-network-based controller

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Abstract

Direct control of unknown time-invariant nonlinear plants is addressed in this paper. The objective is to construct an adaptive control scheme which is able to deal with unknown time-invariant nonlinear plants without using the model of the plant. In this paper, a novel approach to adaptive neurocontrol is presented and illustrated with results of a simulation study.

The approach proposed is based on neural-net-controller and combines self-tuning principle with reinforcement learning. The control scheme is composed of a controller, a utility estimator, an exploration module, a learning module and a rewarding module. The controller and the utility estimator are implemented together in a single radial basis function network (RBFN).

The controller receives as inputs current state of the plant, y, and future reference signal, r, which defines desired plant trajectory. Based on these inputs, the controller generates control action, u. The utility estimator is designed to estimate suitability of the proposed control action. If the estimated suitability, $\widehat{U}$, is low, a random exploration component, δu, is added to the proposed control action in the exploration module. Modified action, $u + \delta u$, is then executed and new reinforcement signal, U, is generated in the environment (rewarding module). Received reinforcement signal, U, is compared with the estimated utility, $\widehat{U}$, and in the case of positive difference, $\Delta = U - \widehat{U}$, the adaptation takes place. Learning method involves structural adaptation (growing neural network) and parameter adaptation of RBFN which implements the controller and the utility estimator. Since RBFN learning is local, only specific operation domain is adapted without detrimental effects on other operating areas. The controller is capable of asymptotically approaching the desired reference trajectory. The exploration–exploitation dilemma is solved with smooth transitions between the two modes. This enables fast exploration response to novel plant dynamics and stable operation in the absence of changes in plant dynamics.

The use of the proposed control scheme is demonstrated with simulated control of time invariant nonlinear plant. No prior knowledge about the plant is assumed and the controller has to begin with exploration of the state space. Smooth transitions between exploration and exploitation of knowledge are shown and the appropriate behavior of the proposed controller is demonstrated.

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A Discrete-time Adaptive Controller for Robots Using Dynamic Recurrent Neural Networks

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ABSTRACT: Most of existing neural network(NN)-based control approaches for robot trajectory tracking almost have been developed in continuous-time systems for robot trajectory tracking because of nice mathematical properties, and a known bound on the NN reconstruction error is assumed to be known[1]. Motivated by Polycarpou and Ioannou[2], and our earlier researches on the neural controller design for robots[3], this paper presents a new discrete time adaptive control approach using generalized recurrent neural networks for robot trajectory tracking, where the whole control algorithm is developed in discrete-time form, the upper bound of the neural approximation error is assumed to be unknown. In the controller design, the neural networks use desired joint trajectory and velocity as inputs instead of the actual joint ones, and the proposed NN-based adaptive control approach integrates a NN approach with an adaptive implementation of discrete variable structure control with a simple estimation law to estimate the upper bound on the NN reconstruction error and an additional control input to be updated as a function of the estimate. The discrete variable structure control with a sector, which is the modulation NN basis functions and the robot state errors, serves two purposes: first, it is used to force the robot state within the state region in which the neural networks are used, when the system goes out of the control; second, unlike sliding mode control used in Sanner[1], it continues to provide an additional control until the system tracking error metric is controlled inside the sector when the robot state is inside the NN approximation region, thus improving the tracking performance. No off-line training and learning is needed for the neural networks, and the overall neural control system of robot guarantees semi-global uniform ultimate boundedness within a neighborhood of zero trackign error.

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Systems Identification in Noise Environment with Hopfield Neural Networks

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1. General relations

Let a discrete dynamic system, in input/output description, mono-variable and time invariant, with noise in output observations, $n(k)$, with zero mean and finite. Let $u(k)$ and $y(k)$ the input and the output of the process, at discrete time k. Then the following recurrent relation is valid:

$$y(k) = \sum_{i=1}^{n_a} a_i \cdot y(k-i) + \sum_{i=0}^{n_b} b_i \cdot u(k-i) + n(k) \tag{1}$$

Let the vector of parameters:

$$\theta = \left[a_1 \quad a_2 \quad \dots \quad a_{n_a} \quad b_0 \quad b_1 \quad \dots \quad b_{n_b}\right]^T \tag{2}$$

and the regressor vector:

$$\mathbf{x}(k) = \left[y(k-1) \quad y(k-2) \quad \dots \quad y(k-n_a) \quad u(k) \quad u(k-1) \quad \dots \quad u(k-n_b)\right]^T \tag{3}$$

the equation of identified system is:

$$y(k) = \mathbf{x}^T(k)\theta + n(k) \tag{4}$$

The problem is to estimate the parameters $\hat{\theta}$ and to verify the equation:

$$\hat{y}(k) = \mathbf{x}^T(k)\hat{\theta} \tag{5}$$

and to minimise the mean squared error:

$$V(\theta) = \frac{1}{2}E\left\{e^2(k,\theta)\right\} \tag{6}$$

where

$$e(k,\theta) = y(k) - \mathbf{x}^T(k)\hat{\theta} \tag{7}$$

Based on Hopfield neural networks, we must define an energy function

$$J = -\frac{1}{2}\mathbf{v}^T\mathbf{W}\mathbf{v} - \mathbf{v}^T\mathbf{p} + \mathbf{v}^T\mathbf{v}\sum_{i=1}^{n}\frac{1}{2r_i} \tag{8}$$

where $\mathbf{v}$ is the output of neurones, $\mathbf{W}$- the weights matrix and $\mathbf{p}$ the bias vector.

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If (6) is developed, then:

$$J = \frac{1}{2}\theta^T \cdot E\left\{\mathbf{x}(k)\cdot \mathbf{x}^T(k)\cdot\right\}\cdot\theta - E\left\{y_p(k)\cdot \mathbf{x}^T(k)\right\}\cdot\theta + \frac{1}{2}E\left\{y_p^2(k)\right\} \tag{9}$$

This expression will be considered as energy function of Hopfield neural network, where:

$$\mathbf{v} = \hat{\theta} \tag{10}$$

$$\mathbf{W} = -E\left\{\mathbf{x}(k)\cdot \mathbf{x}^T(k)\cdot\right\} \tag{11}$$

$$\mathbf{p} = E\left\{y_p(k)\cdot \mathbf{x}^T(k)\right\} \tag{12}$$

In this case, the output of neurones will be the estimated parameters.

2. Identification in noise environment. The contribution.

Let the parameters vectors: $\theta=[0.25, -0.223, 0, 0.55, 0.214]^T$. The input signal is binary pseudorandom. The activation function of neurones is $g(x) = tanh(x)$. The number of neurones is equal with the number of parameters.

We have considered two cases:

- white noise Gasussian, with zero mean and finite variance;
- coloured noise, obtained by an low pass filter with the transfer function

$$H(s) = \frac{1}{0.25s + 1} \tag{13}$$

The results are presented in figure 1, where Q is the number of input-output pairs in the training stage. The parameters a_1 and b_2 are biased, only in the coloured noise.

To eliminate de bias from the parameters estimation, we have considered that the model of the process is with τ grater then the real value. Then, the model is:

$$\hat{y}(k) = \mathbf{x}_m^T\hat{\theta} \tag{14}$$

where $\mathbf{x}_m$ is the modified repressor vector:

$$\mathbf{x}_m = \left[y(k-\tau-1) \quad y(k-\tau-2) \quad u(k-1 \quad u(k-2)\right]^T \tag{15}$$

In this new case, the results are very promising and it is presented in figure 1 for τ=5 and coloured noise

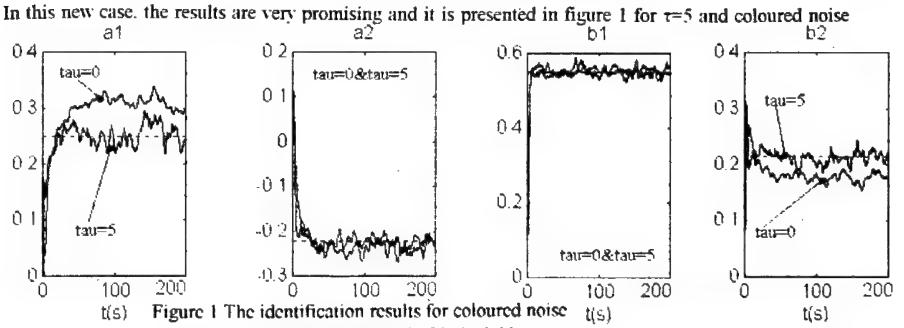

Figure 1 The identification results for coloured noise and modified repressors, $Q = 50$, $\lambda = 0.01$.

PARAMETER IDENTIFICATION OF THE DYNAMICAL SYSTEMS USING NEURAL NETWORKS.

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ABSTRACT

The application of neural networks for parameter identification of linear dynamical system is considered. Modern developments in the science and technology of dynamical systems and their control along with the parallel advances in computers have been widely recognized to have enormous impact on the process of decision making in complex systems in a broad sense. That is why, present industry is demanding an adaptive controller to improve the performance. The adaptive controller, also known as adaptive regulator, consists of two main loops. The inner loop consists of the process and an ordinary feedback regulator. The parameters of the regulator are adjusted by the outer loop, which is composed of a recursive parameter estimator and a design application. There are a number of techniques available for parameter identification, but they are mostly off-line identification. The improvement of identification process is worth considering, as it plays a very important role in the development of adaptive controller. There is lot of scope to improve this. The neural network method is one such move for identification of parameters.

An artificial neural network (ANN) is a network to mimic the performance of biological neural networks. The neural network model consists of many nonlinear computational elements operating in parallel and arranged in different model to resemble biological neural networks. The trained neural networks can be used to approximate an arbitrary input-output of a system. The same ideas can be used for system identification and parameter identification. Hence neural network-based-methods provide attractive alternative for development of highly efficient adaptive controller.

A single layer neural network is proposed for identification of system parameters. We are proposing an improved gradient descent technique for single layer neural networks to identify the parameters of the system whose states, derivatives of the states and inputs are given. The system model is assumed as state variable modes here, the identification of parameter, is obtaining the elements of system matrix (A) and input matrix (B). Generally the method proposed by authors is nearly 50 times faster than the existing method.

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Robustness of Fuzzy Control

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ABSTRACT: The paper deals with the robustness of fuzzy control. It has been shown that under certain conditions fuzzy controllers are a superset of linear controllers. The same is valid for neuro-fuzzy models: they are a superset of linear models. Actually, nonlinear models - as treated in this paper - can be interpreted as consisting of a set of linear models and a soft switch. Every linear model contributes to the output according to the fulfilment grade vectors of membership functions on the universe of discourse.

In classical robust control, a nominal plant model is chosen and a constant controller is designed to satisfy the basic equation of the robust stability: $\|\Delta WT\|_\infty < 1$ where T is the complementary sensitivity function (the transfer function of the closed loop). ΔW the multiplicative uncertainty of the plant and $\| \|_\infty$ the ∞ norm (the least upper bound of the absolute value). If the actual plant is presumed to consist of a set of linear models (which might be diversified with respect to the gain and the time constants) the multiplicative uncertainty is large. The nominal model is chosen in such a way that the multiplicative uncertainty is less than one at low frequencies, while at higher frequencies the fulfilment of the basic equation of the robust stability is assured by shaping the complementary sensitivity function T. Since the multiplicative uncertainty of the plant is large, the complementary sensitivity function must be small. This results in poor performance by the classical robust control.

In the case of neuro-fuzzy models the controller consists of a set of controllers which correspond to the set of models. Every controller contributes to the control variable with regard to the contribution of the corresponding model. Since the uncertainty of the individual linear models is much smaller than the uncertainty of the entire nonlinear model, the complementary sensitivity function may be larger, and better control performance can be achieved.

The effectiveness of the fuzzy control in comparison with classical robust control will be illustrated on an example of the discrete time nonlinear process described by the following differential equation
$y(k) = 0.8930y(k-1) + 0.0371y^2(k-1) - 0.05y(k-2) + 0.157u(k) - 0.05u(k)y(k-1)$
where $u(k)$ and $y(k)$ are the control and controlled variables respectively.

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On Design of a Single-input Fuzzy Logic Controller

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Abstract

Input variables of existing FLCs are mostly the error and the change-of-error regardless of the complexity of controlled plants. The control input or the change of control input is commonly used as their output variable. Then the control rule table is constructed on a two-dimensional space. This scheme comes from the concept of linear PD(Proportional-Derivative) or PI(Proportional-Integral) controller. Then we can find that rule tables of most FLCs have skew-symmetric property and the absolute magnitude of the control input is proportional to the distance from its main diagonal line in the normalized input space. These properties hold in the general n-input FLC that use error and its derivative terms as fuzzy input variables. Considering these facts, we can derive a new variable called the *signed distance*, which is used by a sole fuzzy input variable in our simple FLC called SFLC(Single-input FLC). That is, the proposed SFLC uses a single input variable even in the general *n*th order controlled plant. So, the control rules are constructed on a one-dimensional space. As a result, the SFLC has many advantages: The total number of rules is greatly reduced compared to the case of existing FLCs, and hence, generation, modification and tuning of control rules are easy. Furthermore, we show via computer simulations using a nonlinear plant that the control performance is nearly the same as that of existing FLCs.

We also ensure that the proposed SFLC is absolutely stable using Popov criterion. Here, the controlled plant is changed to the perturbed Lure system and the SFLC is assumed a nonlinear controller. Then the SFLC satisfying a sector condition is absolutely stable.

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Soft Control of Wastewater Treatment Plants

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Abstract

Wastewater plant control has undergone significant advances during the last two decades or so. Experience gained from the operation of such plants has led to improved plant design and control strategies since effective control of wastewater treatment plants is critically important not only for economic reasons but also to the environment. Manual control of such plants is the norm today since most automatic control techniques based on conventional industrial three term controllers do not provide the level and quality of control necessary to satisfy the stringent environmental specifications imposed by civic and environmental authorities. Due to the complexity of the process, most wastewater treatment plants are usually operated far from optimally. The features which make such plants difficult to control automatically is the uncertainty and vagueness with which their operation and control are characterised and it is these very features which make soft control viable.

In conventional or hard controllers, the knowledge necessary to control a process and the methods for using this knowledge are interrelated and in order to apply such techniques knowledge of the microscopic behaviour of the process under control is required explicitly. In contrast, in soft control there is a clear demarcation of the knowledge and the information about the process data and the inference mechanism for applying this knowledge. As a consequence, explicit knowledge of the process dynamics is not therefore essential. A fundamental attribute of soft control is its ability to work with incomplete and ill-defined information which human operators comprehend best. This permits implementation of human-like control strategies which have hitherto defied solution using any of the conventional techniques. Soft control is thus particularly attractive when the expertise to control a process is readily available, as is the case for wastewater treatment plants.

This paper outlines the design of an inexpensive soft controller using fuzzy logic embedded in a commercial programmable logic controller. The controller is capable of superior performance to existing hard control schemes. The results of a simulation study on a proposed municipal wastewater treatment plant in Greece are presented.

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FUZZY LOGIC VARIABLE STRUCTURE CONTROLLER DESIGN APPROACH FOR NONLINEAR PROCESSES

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ABSTRACT: According to the control theory the biotechnological processes are qualified as nonlinear plants with bounded uncertainties. The model parameters do not remain constant over long periods due to metabolic variations and physiological modifications. On the basis of expert knowledge for particular biotechnological processes, the intervals, representing the variations of the model parameters, can be defined.

In this case, one class of systems which are able to perform high-quality automatic control of biotechnological processes are variable-structure systems. A central feature of variable-structure control is sliding mode. The guaranteed system invariance to parameter uncertainties and external disturbance is the main advantage of the sliding mode. However, the typical chattering responses in sliding mode are undesirable for the delicate and precise regulation of the biotechnological processes. On the other hand, the fuzzy logic control makes the control signal always continuous and smooth while maintaining the merit of the variable structure robust control.

This paper proposes a fuzzy logic controller design approach which is easily implemented and transformated from variable structure control. The biotechnological processes expressed by two nonlinear differential equations with uncertain parameters is investigated. The nonlinear model is transformed into a linear model with parameters varying in definite intervals. Variable-structure control in sliding mode is designed. The control design is carried out such that the derivative of Lyapunov function is negative, which guarantees the state variables will finally approach the sliding mode and stay there for ever. The discontinuous control law is transformed to four control actions which are used in a fuzzy logic controller. The input variables to fuzzy controller are sliding surface, state variable errors (biomass and substrate concentration variations). The linguistics variables Negative Big, Negative Small, Zero, Positive Big and Positive Small are chosen to fuzzify. The output variable from fuzzy controller is dilution rate variation. The Sugeno-Takagi inference system is used. The output of fuzzy controller is calculated as a weighted average of all rules.

Several computer simulations have been made in MATLAB environment using Fuzzy Logic Toolbox and Simulink. The results obtained prove that the designed fuzzy logic variable-structure control can be successfully used for set-point stabilization of nonlinear and uncertain biotechnological processes.

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Stability analysis and fuzzy self tuning control of a nonlinear process with limit points

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ABSTRACT

A self tuning fuzzy controller with scaling factors adjustment is proposed for the robust control of a jacketed tubular reactor which is a nonlinear distributed parameter with time lag system. The process under study is described by a set of nonlinear time dependent partial differential equations. The PDE's are discretized by Galerkin's method of weighted residuals and finite element basis functions.

A common feature on the solution branch of such processes is the occurrence of limit points (or turning points) which represent the boundary between stability and instability of the system. The particular process, has one(cubic), two or no limit points, depending on the value of a scalar constant. It thus follows that the solution branch contains unobservable regions. In this paper for the determination of the limit points an arc-length continuation method is used.

The control objective here, is to maintain the control variable, which is the composition of the reacting mixture at the output of the reactor, within specified operational settings, eliminating mostly input concentration and temperature disturbances. The manipulated variable is taken to be the coolant temperature.

Mathematically what is required for the stability analysis and the design of a robust controller all over the solution branch, is the solution of large, sparse nonsymmetric matrix eigenproblems: not the complete solution which is computational, just the most "dangerous" modes i.e. the eigenvalues with largest real parts. In this paper the eigenvalue problem is solved using the Arnoldi method of solving large and sparse eigenvalue problems

In conventional control theory the analysis of a system is limited to linear dynamical systems and even when the tools of conventional control theory are used efficiently in the design for such systems, are inadequate to achieve satisfactory performance over the entire operating range and they should be adapted if the operating point changes, or the parameters change with time.

The performance of the proposed fuzzy controller over a wide range of step disturbances and operating regions, is compared against a conventional adaptive controller. The two schemes are compared with several methods including, time integral performance criteria such as Integral of Absolute Error (IAE) and Integral of Square Error (ISE).

The proposed fuzzy adaptive controller in comparison with the conventional adaptive scheme, exhibits a much robust response, less oscillations, shorter settling times, overshooting less the manipulated variable. When the comparison is carried out versus a PID controller whose parameters are adjusted to the optimal values for minimising the IAE and ISE dynamic performance criteria, it is shown that the proposed fuzzy adaptive scheme exhibits equivalent performance, if not better than, the optimal PID controller.

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MULTI-DIMENSIONAL FUZZY LOGIC CONTROL of an INDUSTRIAL FURNACE

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INTRODUCTION: Fuzzy logic control is especially suitable for ill-defined nonlinear processes where human experience has the edge over mathematical models. Our work is using a three levels fuzzification system suitable for an industrial funace, namely the start-up, the normal operation and operation at extremes operating conditions phases. Fuzzy logic formalizes the human decision approximate reasoning, that copes with uncertainty and approximation, with membership value (μ) different than 1 and 0. A total multi - level fuzzy logic control of an industrial furnace is suggested.

Combustion dynamics are modeled by look-up tables and process characteristics, while sensors limitations are not considered here. The system was identified and the controller design and stability investigated. The intrinsic physical complexity of the combustion process itself lies in the fact that its parameters are susceptible to changes.

We define three operating regions of the industrial furnace. Even these zones of operation might be ill-defined and form a fuzzy set themselves.

PHASE	START-UP	NORMAL OPERATION	EXTREME OPERATION
TEMPERATURE RANGE	*0 - 300° C*	*300 - 1500° C*	*1500 - 1700° C*

The domain of the fuzzy set is the allowable values of the furnace temperature range at the start-up, the normal operation and operation at extremes operating conditions phases. This approach a multi-dimensional fuzzy set of control variables ranges and membership functions, that corresponds to 3 x 3 matrices.

Other fuzzy modeling points of views might be defined, by the simple use of futher furnace variables (total number n), such as pressure, thermal load, stack flue gases management, fuel combustion, etc. This approach a multi-dimensional fuzzy set of control variables ranges and membership functions, that corresponds to n x 3 x 3 matrices. Tuning of fuzzy controllers is a trial-and-error method process and involves adjusting many parameters.

The Fuzzy Logic Controller (FLC) implements an intelligent furnace control strategy. Fuzzy controllers exhibit superior controller performance compared to conventional strategies, especially for nonlinear, complex processes.

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DIRECT DECOMPOSED RULE BASE FUZZY LOGIC SYSTEMS

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Fuzzy set theory which infers outputs of a fuzzy system with rules composed by an expert was introduced by Zadeh. The main interest has been on building fuzzy relationships systems that are expressed by a set of fuzzy linguistic propositions derived from an expert's knowledge of the system under consideration or a group of observed input-output data. However, for some large complex systems, it is almost impossible to establish such a relationship due to the large amount of the fuzzy propositions and the highly complicated multidimensional fuzzy relationship.

In this paper we propose a new design algorithm of fuzzy logic system, namely Direct Decomposed Rule Base Fuzzy System (DDRB). The proposed algorithm, directly at the rule base generation stage decomposes the rules, thus the rule base size is greatly reduced. The new design method is based on the human expertise or a group of observed input-output data to construct two dimensional relations between merely a single-input and the output vector or a single output depending on the case under consideration.

A DDRB fuzzy logic controllers have been designed and applied to gas turbine systems. The rule base for our system is a two dimensional fuzzy rules. The controller design incorporates in itself feedforward (predictive), hierarchical, and emphatic rule schemes. Thus DDRB fuzzy system is compatible to other advanced techniques and provide a compact and simple structure of fuzzy logic systems.

The DDRB fuzzy logic system applied to gas turbine systems is evaluated using simulation techniques provided by Matlab/simulink Software Package under different operating conditions. Comparisons are made with both the existing PI regulators and the standard fuzzy logic systems. Simulations show that the new design method (DDRB) achieves improved performance over conventional schemes, reduced the complexity of the system, and increased the robustness of the controller.

By using the stated concepts, systems with virtually any degree of nonlinearity can be controlled properly. But it should be pointed out that the methods used for developing fuzzy logic system are possible only if the aggregation of the rules and the defuzzification method are of weighted sum type.

The approach with the methods developed in the paper clearly opens the perspective, i.e., a fuzzy logic system can be developed for modelling and designing of a precision system.

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Applying Genetic Algorithms to Workshop Cell Decomposition

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Abstract:
The layout problem arises in a production plant during the study of a new production system, but also during an eventual restructuration due to a design modification or the introduction of new ressources in the plant. The mean aim of this layout is to lower transportation and manutention, which simplifies management, shortens the lead time, and betters the quality and speeds up the response to market fluctuations.
A tenet of the Group Technology (GT) preconizes the division of a unity into small groups or cells. Products needing similar operations and a common set of ressources are grouped into families, ressources being grouped into production subsystems. This GT as shown to be a key of production optimization and control, and material transport and handling. As it is most of the time illusory to conceive totally independent cells, the problem is to minimise trafic of items between the cells, for a fixed maximum cell size. This problem is known as "workshop cell decomposition".
Workshop cell decomposition is a NP-hard problem, i.e., there does not seem to exist an algorithm of polynomial complexity to solve it. So enumerative methods, while guaranteeing the global optimum crash down for important instances of the problem. Heuristics have been developped to avoid the shelf of the enumerative methods, but they are subject to trapping in local extrema of the cost fuction associated to the problem, sometimes giving poor results.
We propose here an original approach, based on a Grouping Genetic Algorithm (GGA). This is a special class of genetic algorithms, heavily modified to suit the structure of grouping problems. It uses an adapted encoding scheme and special genetic operators. Our algorithm uses a local improvement heuristic based on the work of Haralakis, but slightly modified to introduce a noisy selection in the choose of the cell a machine should be putted in. In short, it puts an object in a cell with a probability related to the strongness of the trafic it has with the machines inside the considered cell.
The crucial advantage of this GGA is that it is able to deal for big instances of the problem. We solved problems known to be deceptive for Haralakis' heuristic with 400 machines in less than three minutes. It thus becomes a powerful tool for an engeneer determining a plant layout, allowing him to try several plant options, without the limitation of huge computation times.

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Application of the Genetic Algorithm Approach to a Cellular Dynamic Channel Allocation Model

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ABSTRACT

Genetic algorithms (GAs) are adaptive heuristic methods that may be used to solve optimisation problems by generating recursively a new population of solutions from an initial one. They have been applied to several combinatorial problems such as the travelling salesman problem with satisfactory efficiency [1]. *Combinatorial* is a problem which is related with the optimisation of a discrete *cost or energy function* that occurs from a specific problem modelling.

Channel assignment is the process of assigning appropriate channels to the individual members of a cellular network and is generally classified into fixed and dynamic. In *fixed channel assignment (FCA),* channels are statically allocated to each cell whereas in *dynamic channel assignment* channels are assigned dynamically. DCA gives the opportunity every cell to use any of the available channels but requires more complex operations than FCA [2].

The use of GAs to various FCA models has been extensively studied in [3], and [4]. A genetic algorithm based DCA for uniform traffic distribution has been suggested in [5]. This paper extends the application of GAs to include further assumptions than [5]. At first an ideal cellular model is assumed. DCA takes the form of a combinatorial problem and a proper energy function is constructed from the assumptions of the model. Simulation results show that GA-DCA achieve a good performance in comparisons with other methods and enhance the idea of further research concerning the use of evolutionary algorithms to other communication problems.

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A Genetic Algorithm for Efficient Video Content Representation

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Abstract

The rapid development of video and multimedia applications has enabled users to handle large amounts of visual information. At the same time, new requirements have emerged for more intelligent access to video databases, i.e., content-based indexing and retrieval, video browsing and so on. For this reason, a new standardization phase is currently in progress by the Moving Picture Expert Group (MPEG) in order to develop an integrated framework for a multimedia content description interface. In this paper, we propose an efficient video content representation using optimal extraction of characteristic frames and scenes of video sequences. This approach not only provides a more efficient way for video indexing, but also results in reducing storage requirements and thus permits easy management of multimedia databases.

The first stage of the proposed algorithm includes a scene cut detection mechanism. Then, a multidimensional feature vector is generated for each frame of the video sequence. This is accomplished by integrating several modules using color, texture and motion information. A hierarchical block-based color and motion segmentation scheme is adopted for exploiting information that exists in the MPEG coding standard [1]. Object tracking is supported by taking into account motion compensated segmentation results of previous frames. The feature vector is formed as a multidimensional "histogram" using fuzzy classification of object properties into predefined categories. Then, optimal selection of representative scenes is performed by minimizing a distortion criterion. This is accomplished by clustering similar scenes and selecting a limited number of cluster representatives. The generalized Lloyd-Max algorithm has been used for this purpose. The next step is to select the most characteristic frames within each one of the selected scenes. This is achieved by minimizing a correlation criterion, so that the selected frames are not similar to each other.

Unfortunately, the complexity of an exhaustive search for the minimum value of the correlation measure is such that a direct implementation would be practically unfeasible. For this reason, a genetic algorithm (GA) approach [2] is adopted in this paper. Possible solutions of the optimization problem, i.e., sets of frames, are represented by chromosomes whose genetic material consists of frame numbers (indices). An initial population of chromosomes is then generated by selecting sets of frames whose feature vectors resides in extreme locations of the feature vector trajectory. The objective function used to estimate the fitness values of all chromosomes, is defined as the sum of squares of cross-correlations between all combinations of feature vectors, for all frame numbers that belong to the genetic material of the respective chromosome. Following a proportionate scheme for parent selection, a set of new chromosomes (offspring) is produced by mating the parent chromosomes and applying uniform crossover and mutation operations.

The GA approach seems to be very efficient for the particular optimization problem, given the size and dimensionality of the search space and the multimodal nature of the objective function. This estimation is supported by experimental results, using TV recorded video streams and demonstrating fast convergence to acceptable solutions.

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EVALUATION OF AN ADAPTIVE FUZZY CONTROLLER BASED ON EVOLUTIONARY REINFORCEMENT LEARNING

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We present the design and implementation of a Fuzzy Learning Classifier System (FLCS), that we have developed to be used as an adaptive fuzzy logic controller. In order to evaluate the behavior of the system, we have also implemented the RFALCON model (Reinforcement Fuzzy Adaptive Learning Control Network) originally proposed by C.J.Lin and C.T.Lin. Both systems are tested on the problem of autonomous vehicle navigation. The two models represent two different approaches to adaptive fuzzy control, evolutionary and neural network. The advantages and drawbacks of the two approaches are investigated based on the experimental results obtained from the respective implementations.

The FLCS is an evolutionary approach to the construction of fuzzy controllers. It produces a set of fuzzy rules using a credit assignment mechanism and a genetic algorithm. The fuzzy rule base is implemented as a set of strings, each string representing a fuzzy IF-THEN rule that maps input space regions to control actions. The condition part of each rule represents a fuzzy hyperbox in the input space. The exact control action (crisp value) is obtained through defuzzification on the set of activated rules for the particular condition. A credit assignment algorithm is responsible for distributing reinforcement to the appropriate rules. A genetic algorithm is applied periodically on the rule set in order to modify existing rules and produce new ones. The reinforcement accumulated by each string serves as its fitness function value for the genetic algorithm. We have designed the FLCS based on the standard Learning Classifier System architecture, enriched with advanced mechanisms in the Apportionment of Credit and Genetic Algorithm subsystems, that are best suited to the requirements of the control problem.

RFALCON is a neuro fuzzy controller, that makes use of a Fuzzy ART (Adaptive Resonance Theory) neural network structure. The fuzzy rule base is formed during the neural network training process. The model is capable of modifying its fuzzy rule base in two ways: by generating new control rules and by modifying its fuzzifier and defuzzifier. RFALCON performs dynamic fuzzy clustering in both input and output spaces, thus creating a set of input space fuzzy hyperboxes and a set of output space fuzzy hyperboxes. A fuzzy if-then rule is a connection between an input hyperbox IH and an output hyperbox OH, which is interpreted as: "IF input is contained in IH, THEN output is set to a value contained in OH".

The two systems have been implemented and tested on Olivier Michel's Khepera robot simulator. Both have succeeded in achieving collision free navigation of the robot in a territory containing obstacles. Extensive tests have shown that the FLCS adapts faster to environmental changes than RFALCON. Also, the FLCS is more flexible in producing new rules and in modifying existing ones to achieve better performance.

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Genetic Evolution of Neural Networks Using Subpopulation Schemes

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Abstract

Although NN's are now well established engineering tools and have been successfully used to address diverse problems, the architectural and topological decision that need to be made during their design still heavily rely on heuristics and trial-and-error approaches.

Artificially evolving a NN that is in a sense "optimal" on the basis of a custom measure, is quite attractive, since it offers a problem-independent methodology for the automatic off-line design of a "well behaving" system. [1]

Research in this area falls into two major areas: (i) evolving the entire network topology (possibly including the connection weight values), and (ii) incrementally building the network by evolving one unit at a time.

In the first case, each individual of the population usually represents an entire network. However, cooperative-competitive genetic schemes have also been proposed which encode one single network in the entire population by assigning one hidden unit to each individual [2]. In this paper, it is argued that subpopulation (and multi-population) genetic algorithm schemes (e.g. [3]) may offer an efficient alternative between these two approaches since:

- They can encode one hidden unit per individual, thus allowing to employ cooperative-competitive evolution among them.
- They can represent more than one networks simultaneously in a population (one per subpopulation) thus enabling the competition among them.

The proposed model can be viewed as a rough extension of the two approaches and can inherit merits from both.

To illustrate the approach, a number of benchmark problems often encountered in the related literature is addressed.

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Evolution and Comprehension of Neural Networks

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Keywords: Neural Network, BP algorithm, Genetic Algorithm, Symbolic Rules.

ABSTRACT

Although artificial neural networks have been proven to be a powerful and general technique for machine learning over a wide range of domains, they are often regarded as "black box" and the result of a network may not be easily applied to related problems. Some of the most significant reasons are the following. First, there is not a problem independent way to choose a good network topology. Second, there is no explanation of the relation between input and output. Third, the format of the result may not be easily used in related problems. With these shortcomings, the application of neural networks are weakened.

Good topologies entail a small number of nodes of the network and a loose connectivity among them. To obtain an appropriate network topology, one of the most important things is to determine the number of hidden units and connectivity among units. GAs are suggested to be very good candidates for searching in the space of topologies, because the fitness function associated with such a space has several properties that make it unappealing for classic methods: it is complex, noisy, nondifferential, multi-model and deceptive. Experimental results support this view.

Without the ability to produce understandable decisions, it is hard to be confident in the reliability of networks that address real-world problems. In this paper, we present an algorithm RulExt which extract rules from networks to understand them. A genetic algorithm is used to prune a trained network; thus, unlike in other literature, there is no constraint on weights and no need to predefine a threshold for the pruning. The pruned network is then converted to several trees, this makes us easy to understand the process of decision making. Finally, rules are extracted by analyzing the trees from root to leaves. The rules are compact and comprehensible, and do not involve any weight values. In this way, we managed to utilize the advantages of Artificial Neural Network, Genetic Algorithm and Symbolic Learning, and avoided some of their disadvantages at the same time.

Although RulExt algorithm takes longer time than some other algorithms, experiments show that RulExt rules are more interpretable while preserving theaccuracy of the networks. Furthermore, the rules are more concise and can be easily used in related fields. By extracting rules from a neural network using RulExt, the neural network should no longer be considered as black box.

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Fast Synthetic Genetic Algorithm Combined with BP and Its Application to Short-term Economic Dispatch of Hydrothermal Power Systems

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Abstract

1 Genetic algorithms (GAs) are probabilistic heuristic search processes based on natural genetic system. They are highly parallel and believed to be robust in searching global optimal solution of complex optimization problems. GAs are capable of solving wide range of complex optimization problems only using three simple genetic operations (selection/reproduction, crossover, and mutation) on coded solutions(strings/chromosomes) for the parameter set, not the parameters themselves in an iterative fashion. GAs consider several points in the search space simultaneously, which reduces the chance of convergence to a local optima. But GAs have some main disadvantages:

(1) slow convergence speed;

(2) premature convergence or stalling;

(3) the larger number of populations and individuals for some complex optimization problems.

2 To overcome the disadvantages and to acquired better performance of GAs, some modified GAs have been proposed and published, some of them are modified by parameter selection and initialization, and the others by crossover operation or mutation operation. To use a better GA effectively, we have compared and appraised some different modified GAs by theory analysis and simulation tests, and found that these modified GAs have certain advantages and disadvantages respectively, to make full use of the advantages of each GA and to make up its disadvantages, we proposed a fast synthetic genetic algorithm (FSGA), and analyzed and simulated it, the results demonstrate that FSGA has faster convergence speed and higher computation precision, and the number of individuals in a population has decreased respectively, therefore it is a effective optimization algorithm.

The fast synthetic genetic algorithm exploits the following technology:

(1) Dynamic parameter encoding and restart technology, that can gradually reduce the search range to overcome premature convergence and can decrease the number of populations and individuals;

(2) Selecting crossover site with unequal probability, it has better convergence properties;

(3) Genetic-catastrophic algorithms, it can effectively solve the premature convergence problem;

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(4) Directed mutation technology, it can guide the algorithm to convergence fast;

(5) Elitist strategy, it can achieve global convergence;

(6) whole substring mutation technology, it can effectively solve local optimum problem with contrary independent variable.

The fast synthetic genetic algorithm use binary coding and is programmed in Matlab language.

3 Artificial Neural Networks (ANN) are gaining popularity in various field of engineering including electrical power systems due to their high computational rates and robustness as well as their modeling complex and nonlinear relationship through a training process with historical data. One of the ANN models extensively used for power system applications is the multilayer perceptron model based on back propagation(BP) algorithm. However, its training requires large number of input-output data sets which increases with system size and requires longer training time. Moreover, the BP algorithm offers slow convergence with random initial weights. Combining it with GAs can shorten training time effectively. Here sigmoid functions are parameter changeable.

4 This paper has applied the FSGA combined with BP algorithm to short-term economic dispatch of hydrothermal power systems. What is called economic dispatch is rationally to distribute the loads in each power plant for making the total fuel (coal) cost minimize. The short-term economic dispatch refer to load dispatch by the day for a lead time ranging from one day to several days or a week out. the load in a day use varying time interval model and the water consumption of each hydropower plant in a day is a given value.

In the present work, only a simplified formulation of economic dispatch of hydrothermal power system has been considered which has been used to minimize total fuel cost of thermalpower plants represented as,

(1)

where, ai, bi, and ci are fuel cost coefficients of ith generator and PGi is real power output, Ng is the total number of generators in all thermalpower plants.

The above fuel cost is minimized while satisfying system equality constraints,

(2)

where, PL is the total network real power loss, PLD is the total real power demand, Wj(PHj) is the water consumption property of hydropower plant, WjS is the given water consumption of hydropower plant in considered time, PHj is real power output of jth generator in hydropower plant.

5 This paper has made simulation studies on a practical power system with one hydropower plant and two thermalpower plant, the simulation results demonstrate that this method is effective and training time is short.

ENTROPY BASED FATIGUE IDENTIFICATION IN SPINAL SURFACE ELECTROMYOGRAPHIC SIGNALS USING WAVELETS

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There are two general areas where the detection and evaluation of muscle fatigue are important. The first one is **socioeconomic** that is related to **ergonomics** (human work load in factories, workman compensation, insurance, etc.) and the second one is the study of the **musculoskeletal disorders**. In both areas the understanding of the characteristics of the surface electromyographic (SEMG) signal is necessary before muscle evaluation criteria will be developed and supporting devices can be designed. Up to date, spectral shift changes of the SEMG signal have been used by researchers to detect localized muscle fatigue during the performance of a specific static task. More specifically, two measures of the power spectrum have been investigated, the **mean** (MNF) and the **median** (MDF) frequency. It was observed that although both MNF and MDF are shifted toward the lower frequency region of the spectrum (during the task performance), the shifts were inconsistently subject sensitive. From the two methods, MDF is less sensitive to noise thus it is the preferred method. These findings raised questions about the usage of MNF and MDF as muscle fatigue indicators. Other researchers have used another method known as the **zero crossings** (ZC) method. A ZC is defined as an event when a signal changes polarity. In practice, it is very difficult to obtain the exact number of ZCs especially if the amplitude of the background noise is higher than that of the SEMG signal.

In this paper we report the results of a restricted study designed to test the **hypothesis** that the **entropy** of the SEMG signal is different at the beginning and at the end of a fatigue test (FT). In our experiment, four subjects were randomly selected. Each subject performed seven one-minute FTs with and without lumbar support. The SEMG signals were recorded (using surface electrodes placed on the spinae erector muscles (L3)) only for the initial and final four seconds of the one-minute test interval. The study of the signal was done by applying a **wavelet** based technique known as **multiresolution analysis** (MRA) using Daubechies wavelet of 16^{th} order. The SEMG signal was decomposed into eleven levels (corresponding to the 4096 data points) and partially reconstructed by summing levels 8-10 only. Subsequently, the entropy of the reconstructed signal was computed for all the test cases involved. The results have shown that the entropy is higher in the final four seconds for all subjects and for all seven cases examined which is consistent with the results obtained by the MDF method. This is significant in the sense that if a statistically large number of test cases shows the same trend, then a new muscle fatigue test could be developed.

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AUTOMATIC ONSET DETERMINATION OF SURFACE EMG SIGNALS UTILIZING WAVELETS

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EMG onset time determination is one of the most useful information in kinesiologic and ergonomic studies. However, the existing methods of determining the onset time do not provide consistent onset time results. It is especially true in examining erector spinae muscles where the EMG signal shows a significant amount of postural activity. Twenty subjects volunteered to participate in the sudden load experiment. EMG signals were recorded bilaterally at L3 level 3cm from the midline. The unprocessed raw EMG data were recorded while a sudden expected load was applied using a weighted ball (6.4N) falling from a height of about 1.8 m onto the pan. Seventy-eight EMG signals were selected for comparing the traditional and wavelet techniques. Selected EMG signals were inspected by two experts to provid the "best" control for comparing many techniques. A combination of thirty-six different criteria has been evaluated for traditional onset determination. That is, four signal processing techniques (RMS_25, LPF_10 Hz, LPF_50 Hz, and LPF_250 Hz), three scale comparison parameters (1, 2, and 3), and three moving-window sizes (10ms, 25 ms and 50 ms). Five different types of wavelets, Daubechies D4, Daubechies D8, Daubechies D16, Coiflet C3, and Symmlet S6, were used to determine onset. Three parameters were estimated from signal-to-nose ratio to provide better onset determination after the wavelet transformation. The wavelet based onset determination outperformed the traditional techniques. The average onset determination error when using wavelet based techniques was approximately 5 ms. There were statistically significant differences between the classical techniques and wavelet based methods (ANOVA, $\check{p} < 0.0001$). Considering the fact that the accepted resolution of on-off times of muscle activity is 10 ms, this wavelet based techniques provided far superior resolution in most EMG signals. Wavelet based analysis has been successfully applied for the automatic onset time determination from low back surface EMG signals. The results indicated that the onset time detected by wavelet methods provided more precise onset detection that traditional methods.

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Contour Recognition Using Matched Filter and Wavelets

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Extended Abstract

Contour recognition systems are often used for special applications e.g. quality control systems [1]. The contour recognition is always related to feature extraction problems. It is most desirable to have features invariant to shifting, rotation and zooming of the contours.

In this paper, a method of closed contour recognition is presented. The method is based on a parallel recognition scheme which represents a matched filter in parallel to recognition units of geometrical features [7]. For the extraction of the contours we applied the OCE method [1] which results closed contours directly. From the closed contours we calculate the contour descriptors using the lenght of the edges and relatives angles between two neighbouring edges. This description ensures an invariance of the contour with respect to shifting, rotating and zooming. In the next step we applied different types of transformation to extract the features in spectral domain, namely unitary transforms like Haar and Walsh transform [2], piecewise linear transforms PHL (Piecewise linear Haar transform) [3] and PWL [4], and finally different types of Wavelet transforms (Haar, Daubechies, etc.) [5],[6]. The spectral coefficients are treated as inputs of the matched filter. Then we calculated geometrical features: size of area, center of gravity and full length of the contour. Then these features are combined and the recognition results are compared and discussed.

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To check the compression quality of the transforms we reject parts of the coefficients and the recognition stage is repeated, also with combinations of different features. To check the quality of recognition, we added stationary Gaussian noise to the contour and the SNR (signal-to-noise ratio) is calculated. In an experiment we recognize different types of contours (sharp and smooth contours) with different compression ratios and additive noise. The average number of recognition errors versus SNR for different compression ratios is analyzed. The plots of this recognition are also shown for different transforms and different combinations of features.

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A Lattice Calculus Unification of Min–Max Control Systems of the Morphological and Fuzzy Type

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ABSTRACT: Discrete-time dynamical systems can be described in state space by

$$x(k+1) = f(x(k), u(k), k) \quad , \quad y(k) = g(x(k), u(k), k) \tag{1}$$

where x is a n-dim state vector, u is a r-dim input or control vector, and y is a m-dim output vector. The well-known *linear control* systems deal with linear f and g, i.e., $x(k+1) = Ax(k) + Bu(k)$ and $y(k) = Cx(k) + Du(k)$. Recently, there have been some classes of *nonlinear* systems with a broad spectrum of applications whose state-space dynamics can be described by (1) via appropriate nonlinear choices of f and g. One broad such class is described by

$$\begin{aligned} x(k+1) &= (A \boxed{\vee} x(k)) \vee (B \boxed{\vee} u(k)) \\ y(k) &= (C \boxed{\vee} x(k)) \vee (D \boxed{\vee} u(k)) \end{aligned} \tag{2}$$

where the components of the vector $x = [x_1, x_2, ..., x_n]^T$, of the vectors or scalars u, y and of the matrices $A \in \overline{\mathbb{R}}_{n\times n}$, $B \in \overline{\mathbb{R}}_{n\times r}$, $C \in \overline{\mathbb{R}}_{m\times n}$ and $D \in \overline{\mathbb{R}}_{m\times r}$ are from $\overline{\mathbb{R}} = \mathbb{R} \cup \{-\infty, \infty\}$, $\vee$ denotes pointwise maximum (or supremum), and the *max-sum matrix 'product'* $\boxed{\vee}$ of a $m \times n$ matrix $A = [a_{ij}]$ with a $n \times p$ matrix $B = [b_{ij}]$ is the $m \times p$ matrix $C = [c_{ij}]$ defined as

$$C = A \boxed{\vee} B \quad , \quad c_{ij} = \bigvee_{k=1}^{n} a_{ik} + b_{kj} \tag{3}$$

with $a + (-\infty) = -\infty$ for any $a \in \overline{\mathbb{R}}$. Special cases of such systems (2) (i.e., special choices of A, B, C, D) have been used in [2, 4] to model the dynamics of *discrete event dynamical systems (DEDS)* (see [1] for a survey of DEDS) as applied to material flow in manufacturing systems and related scheduling problems. The underlying nonlinear matrix operations are the basis of the *minimax algebra* [3], which has found numerous applications in DEDS and operations research. In typical applications of Eqs. (2) to model DEDS, the states $x_i(k)$ may represent the start-up or completion time of the k-th cycle of machine i, the input or control u represents availability times of parts, y represents exit times, and the elements of the matrices A, B, C, D represent service/delay times or activity durations. However in other application areas, Eqs. (2) can also model the dynamics of *morphological filters* described by max-sum (or min-sum) difference equations [9, 10] and used widely in nonlinear signal processing and image analysis [7, 8, 11, 5]. We refer to the system-theoretic and control aspects of nonlinear dynamical systems described by (2) as **max-sum control**.

A *dual* algebraic model for **min-sum control** is obtained by replacing in (2) maximum ($\vee$) with minimum ($\wedge$) and the max-sum ($\boxed{\vee}$) with a min-sum matrix product ($\boxed{\wedge}$):

$$C = A \boxed{\wedge} B \quad , \quad c_{ij} = \bigwedge_{k=1}^{n} a_{ik} +' b_{kj} \tag{4}$$

with $+'$ being regular addition extended by the rule $a +' (\infty) = \infty$ for any $a \in \overline{\mathbb{R}}$. The max-sum and min-sum control systems are closely related to morphological systems because the outputs of the former are morphological convolutions of the input and appropriately defined impulse responses.

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Another broad class of nonlinear dynamical systems is obtained by replacing in (2) the max-sum matrix product ($\boxed{\vee}$) with the following max-min matrix product ($\boxed{\diamond}$):

$$C = A \boxed{\diamond} B \quad , \quad c_{ij} = \bigvee_{k=1}^{n} a_{ik} \wedge b_{kj} \tag{5}$$

The corresponding state equations are:

$$\begin{aligned} x(k+1) &= \left(A \boxed{\diamond} x(k)\right) \vee \left(B \boxed{\diamond} u(k)\right) \\ y(k) &= \left(C \boxed{\diamond} x(k)\right) \vee \left(D \boxed{\diamond} u(k)\right) \end{aligned} \tag{6}$$

The max-of-minima operation in the max-min matrix product underlies the addition of two fuzzy numbers [6]. Thus, systems described by (6) can model *fuzzy/probabilistic control* systems and are also encountered in fuzzy neural nets. In such applications, the elements of the vectors and matrices involved in Eqs. (6) represent probabilities, likelihoods, or memberships.

One major goal of this paper is to **unify** these two broad classes of **min-max control** systems: (1) the max-sum and min-sum control systems described by (2) and its dual and used to model both material flow and scheduling problems in DEDS as well morphological systems of nonlinear signal/image analysis, and (2) the max-min control systems of (6) used in fuzzy control and fuzzy neural nets. The unification is done in the framework of the **complete lattice** $(\overline{\mathbb{R}}^n, \vee, \wedge)$ and starts from the ideas used in [11, 5] to extend morphological signal convolutions (of the max-sum or min-sum type) to abstract lattices. Specifically we show that the max-sum and max-min matrix operations are special cases of operators $\mathcal{D}[\bigvee_i v_i] = \bigvee_i \mathcal{D}(v_i)$ acting on the above complete lattice that distribute over suprema; such operators $\mathcal{D}$ are called lattice **dilations**. The dual min-sum and min-max matrix operations are special cases of lattice **erosion** operators that distribute over infima. Lattice dilations and erosions when combined in series or in parallel or when iterated (as in state-space) produce new lattice operators with many interesting algebraic properties. Thus, the above two broad classes of min-max control systems (i.e., max-sum control for DEDS and morphological systems and max-min control for fuzzy systems) are unified in a common framework where both are described by nonlinear equations representing lattice dilations (or dually, erosions) in state space. Another contribution we present in this paper is the study of the system-theoretic and control aspects of the min-max control systems in the above unifying lattice-theoretic framework.

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Face Recognition based on Multiple Representations: Splitting the Error Space

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Abstract

An innovative scheme that produces a computerized system suitable for real time face identification and recognition is proposed in this work. It involves the creation of a dynamic face storage database coupled with an identification algorithm.

The system aims at recognizing faces irrespectively of orientation, scale and texture transformations [1]. This is achieved by using different identification algorithms that mutually solve the exclusive problems that correspond to the different transformations; a decision mechanism is used subsequently to select the most reliable result. The positioning of faces to be recognized within the image is assumed to be a-priori-known; thus the face is considered to be in "head format" [2]. Splitting of the error domain due to the above-mentioned transformations is proposed in this paper, using exclusive descriptors that successfully represent faces under specific conditions. Due to these exclusive descriptors, the scheme leads to successful parallel partial solution of the face recognition problem. The face database, which is used in the recognition procedure, includes three feature sets extracted from each face. The two sets are based on geometrical moments and the other one on singular value decomposition of the image. The need to preserve the facial input geometrical space topology leads to the usage of two Self- Organized Maps [3]. Each map uses variant moment discriminators (VMD), representing facial texture, as its training set and clusters the input vectors by recognizing correlation and hidden similarities among them. The identification procedure for the VMD representations is the following: Each SOM accepts the VMD of the input face as its input and provides the nearest cluster to its output. Appropriate linear vector quantization (LVQ) networks are then applied to this cluster, providing the final identification. To handle problems of facial variations, e.g. partial disguise, we include a third representation of faces in the database, consisting of a singular value set that contains the most significant singular values of each facial image. Through these values a primary least squares image reconstruction technique is constructed and a group of the faces, which is nearest to the presented one, is extracted. A decision rule is then proposed which compares all the above-derived results and accepts the most reliable of them. Real images, taken out of the face database created at the University of Bern, are used in this paper to illustrate the performance of the proposed method.

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Necessary and Sufficient Conditions for Stability of Dynamic Fuzzy Systems

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Abstract

This paper discusses the stability analysis of a generalised class of continuous fuzzy systems in terms of Lyapunov stability theorems. The fuzzy system is described by Takagi-Sugeno model

$$IF\ (x\ \ is\ \ X^i)\ \ THEN\ \ x^{(n)} = a^i{}_0 + \sum_{l=1}^{n} a_l{}^i x^{(l-1)} \qquad (1)$$

Most of the research works that deal with the stability issue, assume that $a_0{}^i = 0$ in equation (1). Then they conclude that the fuzzy system which is resulted from blending of all the linear sub-systems, is asymptotically stable in the large if there exists a positive definite matrix P such that $\forall i$, that is for all the sub-systems,

$$\left(A^i\right)^T P + PA^i < 0 \qquad (2)$$

In the present work, it is assumed that $(a_0{}^i \neq 0)$ in equation (1), in order to study its effect on the stability of the resultant fuzzy system.

As a result of this work, new stability theorems are proposed to examine the stability of general form of Takagi-Sugeno model. In accordance with the proposed theorems, the stability condition represented by equation (2) will no longer be enough to assure the stability of the fuzzy system (1). Therefore, the new stability theorems, in addition to equation (2) represent a new approach to test the stability of fuzzy systems taking into consideration the absolute part $(a_0{}^i)$.

By this technique, Takagi-Sugeno fuzzy model, which has been proved as an excellent tool for dynamic modelling, may be widely applied in control applications, as we show with an application example.

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Premise Aggregation with Fuzzy Logic Operators *

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The fuzzy logic operators are used to decide the following multicriteria decision making problem. A finite set of alternatives is evaluated by a set of fuzzy criteria, i.e. fuzzy relations, which may be either fuzzy preference, or simmilarity, or likeness relations. The problem is to construct an evaluation procedure to compare the set of alternatives according to the whole set of criteria, i.e. to aggregate the private fuzzy relations as the union relation be the fuzzy one enchancing to decide the ranking, choice or cluster problem.

The following fuzzy logic operators for aggregation are suggested: Weighted Mean, MinMax, MinAvg and Gamma operators. Some properties of these operators, required to decide the ranking, choice or cluster problems and depending on the properties of the private relations, are proved.

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AN ARRAY ARCHITECTURE FOR SYNTACTIC PATTERN RECOGNITION

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Syntactic methods are an important tool for tackling recognition and classification problems. In areas such as the analysis of natural languages, or even speech recognition, the syntactic approach gains wide interest by scientific community. The complexity of the patterns and the wide variety of the features that characterize them, makes impractical the use of common decision-theoretic approaches [1]. In many applications; such as the processing of biomedical signals (e.g., ECG, EEG, etc.), syntactic methods have been considered as an alternative way of simultaneous detection and classification of some characteristic complexes of these signals. [2]

The kernel of all such methods is the parsing algorithm, which is responsible for analyzing the complex object into a sequence of primitives patterns. The complexity of the parsing procedure depends on the class of the underlying grammar. Context-free grammars combine satisfactorily both the expressive power and the simplicity in their analysis. They can describe many features of natural languages and are widely used in syntactic pattern recognition applications.

Many efficient parsing algorithms have been developed for this specific class of grammar [3]. Earley's parsing algorithm is the fastest sequential algorithm that can parse a CF grammar, without requiring to be in Chomsky or any other normal form. The time complexity of this algorithm as Graham et al. showed in [4] is $O(n^{2.81})$ which can be a significant overhead for reasonably large n. Consequently the efficient parallelization of Earley's algorithm is of particular importance to the above areas. One of the most known parallel implementation of Earley's algorithm in the literature, is that of Chiang and Fu [5]. Chiang and Fu proposed a 2-D VLSI array having $O(n^2)$ array cells and O(n) processing time.

On the other hand, the feasibility of the automatic parallelization of some special classes of sequential algorithms like nested DO (FOR) – loops has been examined in [6]. The minimum parallel time of execution as well as, upper and lower bounds for the number of processors, needed to achieve that time, have also been investigated for this special case, providing with optimal methods

We indicate that, Earley's algorithm is very close to the aforementioned form of nested loops, and we implement it into special purpose hardware, using an optimal method proposed by Andronikos and Koziris in [6]. This method makes an efficient mapping of the loops iterations, using the less possible processing elements. Every distinct chain of succesively depended iterations is mapped into the same processing element. We thus implement Earley's parsing algorithm into a 1-D array architecture, consisted of O(n) processing elements, reducing significantly the hardware complexity.

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Intelligent Retrieval of Temporal and Periodic Data

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A Temporal References Relational Model called TRRM [Bax96] has been designed and implemented. TRRM is a temporal extension of the classical relational schema. In this model, temporal reasoning is performed by a temporal logic interpreter, called TRLi [PG95].

Furthermore, an intelligent prototype system for retrieving temporal and periodic data has been developed based on the advantages of a temporal database and a temporal logic, i.e., TRRM and TRLi.

The communication of the database and the TRLi is mediated by the TRLi -TRRM meta-interpreter. This tool provides an interface to the user for inserting queries in TRLi language and for getting the corresponding results. However, the basic task of the meta-interpreter is to interpret the queries inserted in a suitable form for the TRLi to SQL queries, process them, retrieve the data from the database and transform them to a suitable input to the TRLi.

The system was tested in two application domains. The first implementation was applied to the domain of transportation, on which the use of periodic data is required. The second implementation was applied to the domain of an equivalent database described in the paper "A Consensus Suite of Temporal Database Queries" [J93]. The results of [J93] are compared with the ones resulted from our system. Actually 109 from the 146 queries have passed successfully. Although the results are quite important, the developed prototype needs further extensions in order to become a complete tool that deals with temporal and periodic data. Actually, we are planning to:

- implement a component responsible for the maintenance of data integrity in the database,
- deal with multiple time granularities,
- consider valid time with different semantics in order to cover the idea of periodic valid time,
- extend the functionality of TRLi in order to cover the non-passed queries of [J93].

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Content-based audio retrieval using a generalized algorithm

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Multimedia data are generalized multidimensional composite signals in spatio-temporal domain (e.g. color images are two-dimensional data, each color composed of red, green, and blue signals.) Each type of multimedia data can be divided along all its physical dimensions and converted into a hierarchical structure called *k-tree*. The k-tree structure allows us to use a unified and consistent representation for any data type, with embedded spatio-temporal information for each data type; it also supports multiresolution processing.

Our previous experiments [1] used the k-tree (where k=2) of color histograms as the index to search an image database. It represented the "*restricted query format*" approach because the incoming image clip query was scaled up to match the size of the normalized images stored in the database. Although the experiments demonstrated good results for searching by thumbnails and equal-size images, it could not perform well for searching the position of image clips contained within the stored images.

In this paper, we present a more generalized algorithm for searching multimedia data by content using "*queries with unrestricted formats*". This algorithm now allows us to search data in a multimedia database and find those that contain the same "object" as the incoming query; since no scaling is performed on the query, and it represents the *"unrestricted query format"* approach. We discuss theoretical complexity issues and present experimental results of applying this algorithm to image searching using unrestricted image clip queries. We compare these results with our previous work that used restricted query formats.

The brief description of the algorithm is as follows:

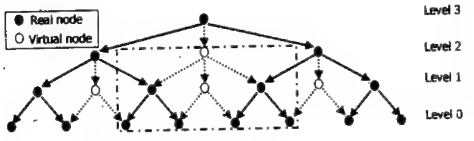
Step 1: Find candidates

Calculate the "feature distances[3]" between the root of the query tree and the roots of all data trees in the database, (assume that data size are larger than the query size.) Then, select those data types for which the distances are below a threshold value. These candidates will be searched at a higher-resolution level in Step 2 below.

Step 2: Determine the position

Case a) The query's tree aligns within the k-tree structure of data:

Find the feature distances between feature in root of query tree and nodes of data at level L_{i-1} -- nodes with solid-line link in the figure below -- of the stored data. If the distance between a child node is equal to that between the query and its parent (L_i), the query may be found within that child node. Repeat (a) recursively on this child node. If there is no distance at level L_{i-1} close to the distance to the parent, the query is "not aligned". Follow Case b) below.



Case b) The query data falls in between two or more nodes:

If no node in k-tree (darker nodes in the figure above) can be a candidate, virtual nodes (dot-line nodes) between two nodes have to be generated from the parts of their child nodes. Then, repeat the whole algorithm into a new tree i.e. use the whole algorithm within the dashed box in the figure.

Case c) If height of query is equal to a node height, use our previous algorithm reported in [1]

Time complexity of this algorithm is searching time $O(k \log n)$ plus time for generating virtual nodes $O((k+1)^4 \log n)$, where k is a number of spatio-temporal dimensions and n is size of each dimension.

We present experiments that demonstrate use of this algorithm for searching for an audio clip in a large audio database. Results of our improved algorithm show more acceptable perceptual querying results than those we obtained earlier with the *"restricted query format"* approach, with better response time.

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AN EFFICIENT PC-BASED ENVIRONMENT FOR THE IMPROVEMENT OF MAGNETIC CORES INDUSTRIAL PROCESS

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Abstract

In an industrial environment dealing with distribution transformer construction, prediction of iron losses of individual cores is a crucial task since the latter significantly affect both the quality and the performance of the final produced three phase transformers. However, there is no simple analytical relationship for estimating of the iron losses due to the fact that many parameters, both qualitative and quantitative, are involved in the process. In the industrial environment considered, several statistical measurements have been shown that a maximum absolute relative error of approximately 20%, in relation to the theoretical specific iron losses, is usually observed.

Computer-aided control and intelligent systems (PC-based environment) which are able to learn and interpret several variations of the same condition can help in such direction. In this paper, we propose a multilayer feedforward neural network structure for predicting the individual core iron losses. In particular, we survey wound core distribution transformers. Several production parameters have been examined which seem to affect the iron losses and then are fed as input vectors to the network structure. Examples include grain oriented steel electrical characteristics, cores constructional parameters, quality control measurements of core production line and transformers assembly line measurements of a real industrial environment.

Various learning algorithms such as the variants of backpropagation or the LVQ (learning vector quantisation) are used to train the network based on a proper learning set. This set comprises about a thousand of measurement sets during transformer construction. However, for maximising the network performance to data outside the training set (i.e., minimisation of the generalisation error) several network sizes have been examined in a constructive framework. A validation data set has also been used during the training process to control learning with respect to generalisation ability of the network.

Experimental results indicating the good performance of the neural network scheme as far as the iron loss prediction is concerned are presented. It is shown that the neural network approach produces an average absolute error of 2.3% in the prediction of specific iron losses of individual cores instead of 5.7% obtained by the current practice. These results are very important since individual core losses significantly affect the distribution transformer losses, which constitute a notable amount of the total losses in distribution networks. Moreover the price of a transformer is inversely proportional to its core losses and full-load copper losses.

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CLASSIFICATION OF PARTIAL DISCHARGE TRANSIENT PATTERNS USING TEXTURE ANALYSIS ALGORITHMS

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ABSTRACT

Partial discharge (PD) is an electric discharge that do not completely bridge the electrodes . PD phenomena gives rise to electric pulses having a magnitude (q) and a phase position (() with respect to the applied voltage waveform. The behaviour of PD pulses varies with time. PD measurements can be applied for monitoring the condition of electrical insulation. Classification of PD sources is an important step in the assessment of the insulation conditions . The most common PD finger print is formed by pulse height analysis using the ((- q - n) patterns, where n is the repetition rate of PD pulses. Conventionally, the classification PD sources has been done with the help of the shape of these patterns.

Texture analysis has been successfully applied in the field of pattern recognition especially in the image processing application , where texture feature contain information about the spatial distribution of spectral variation . This property of texture feature has properly not been used to study the characteristics of PD pulses. This paper, for the first time, evaluates the ability of four texture analysis algorithms for classifying PD sources. The algorithms which have been examined are the spatial grey level dependence method (SGLDM), the grey level difference method (GLDM) , the grey level run length method (GLRLM), and the power spectral method (PSM)] . A comparison of these algorithms with the conventional analysis method for PD classification has been carried out for four different PD sources. The PD sources which have been used in this study include Glow Corona, Streamer Corona, Surface discharge including leader corona , and internal discharge.

The maximum likelihood classifier (MLC) has been used for classification. Seperability measurement, using transformed divergence analysis has been used for selecting the optimal features for each technique to insure that no more features than necessary are utilised when performing classification. The results obtained indicate that , although it is difficult to fully characterise the transient data, it is shown that by extracting only a portion of the transient waveform through systematic sampling technique, these algorithms can provide an effective feature set for classification.

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REAL TIME TOOLS FOR TRANSACTIONAL SYSTEMS DEVELOPMENT

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Abstract: Real time transactions are implemented by client-server applications, which must have a very good response time and which are particularly difficult to realize. We have created three instruments used for developing multi-user software products that manage geographically distributed data. Client users have a graphical displaying of the database placed on the server (actually they have the data displayed on a map) and they can easily make queries by selecting with a mouse the region or the object in which they are interested. Multiple users can access the database concurrently for reading and updating by network, modem or serial cable.

PROCESS OPTIMIZATION SYSTEM USED IN METALLURGICAL PLANTS

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Abstract: The paper presents an integrated system designed for the agglomeration factory and cowper stove process optimization. The system is based on a RT-ARCH (Real Time ARCHitecture)[1], an architecture of software tools used in process control.

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Intelligent Guidance in a Virtual University

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Virtual Reality technology has introduced a new 3D spatial metaphor with very interesting applications on Intelligent Navigation [1], social behaviour over virtual worlds [2], full-body interaction [3], etc. Given the most recent specifications of VRML 2.0, [4], behaviours can be supported through an internal execution model. The execution model is an event mechanism that allows the user to propagate data values as events between fields of nodes. In addition, VRML 2.0 supports interaction with JAVA through script nodes (JSAI, Java Script Authoring Interface) or through external calls (EAI, External Authoring Interface), extending in this way its user interface capabilities.

In this paper, we present the architecture of a Virtual Reality Application which proposes an approach towards Intelligent guidance in a Virtual University. The ground plans of the main University Building have been transformed into 3D VRML models and an Intelligent Agent has been designed and implemented as a virtual representation of a walking human being (avatar) in order to guide visitors around the University. Moreover, we have developed a spatial graph which provides routes through 'information-promising' nodes of the Univesity Building, such as Offices, Laboratories, Amphitheaters, the Central Library, etc. Each node of the graph corresponds to a 3D point of the VRML model. Some nodes (e.g. office nodes) are linked to HTML pages, course presentations, documents, video, etc. The guide tries to perceive the needs of the visitors by query-answering and with the support of a Knowledge base, that runs on a reasoning engine lying into the core of the Intelligent Guide. The Guide plans its route through the spatial graph and communicates with the users through a JAVA applet that manipulates the VRML scene.

We are currently working on linking the University Guide with the Library Data Base system, extending the architecture to become multi-user and including complex behaviours on objects of the VRML world such as other agents, elevators, simple virtual computers, etc.

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A HYBRID NEURAL-CLASSICAL STRUCTURE FOR THE MODELLING OF A BIOPROCESS

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Bioprocesses are highly nonlinear processes generally characterized by sparse and asynchronous measurements. Their kinetics are difficult to model analitically, hence structures like neural networks have been employed to solve this problem as they have proved performant in dealing with nonlinear system modelling. Black box as well as hybrid structures have been proposed for the modelling of this kind of processes. Black box models use only neural networks, while hybrid ones put together neural networks and *a priori* knowledge about the studied process.

This paper proposes a *hybrid structure*: *a priori* knowledge (describing the mass balances) + a radial basis function network (describing the nonlinear reactions kinetics within these mass balances). The aim is to build a *continuous simulator* capable to reconstruct from initial conditions the trajectory of state variables (i.e. the main component concentrations) by considering also an aspect which usually is not taken into account in bioprocesses analysis: the existence of important measurement errors.

The process is a *batch animal cell culture* for which a few measurements concerning four variables are available: glucose, glutamine, lactate and biomass.

A *hybrid training procedure* is applied:

1) *unsupervised* for the centers of the radial basis functions. Several clustering procedures have been tried for the choice of the hidden neurons centers: k-means, fuzzy clustering, Kohonen maps and the best structure from the final cross validation error point of view has been selected.

2) *supervised* for weights and biases. A batch training procedure is applied and in the cost function expression *only* the real data are used. A nonlinear optimization technique (Levenberg-Marquardt) is applied for the weights and biases determination. An analysis based on error is carried on: the cost function is weighted with the standard deviation associated to each measurement point.

All clustering techniques lead to the same optimal structure (the same number of hidden nodes). The satisfying results in cross validation prove that such a hybrid architecture trained with the described hybrid procedure is suitable for modelling a batch bioprocess.

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Fuzzy and Neural-computing in Fabrics Inspection System

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ABSTRACT :

This paper describes the development of a computerized vision inspection system based on image processing and recognition algorithms. The purpose of the developed system is for the **quality control of fabrics and weaving products** from a textile factory. In addition to the use of standard image processing functions for enhancing and modifying the digital image, techniques from **fuzzy reasoning and neural network** have been used for fabrics inspection and recognition. Excellent results have been obtained, which has resulted in saving in manpower and time as well as increased accuracy in the inspection process.

The **requirements** for the systems are as follows : (1) Detection of defects on fabrics product as it moves through the image acquisition unit. The irregularities are detected as defects. (2) The defects are grouped according to size, direction, shape and graded in terms of severity. It should be mentioned that the defects can come in complicated and irregular shapes. (3) Defect locations and their images can be displayed on monitor in real time. (4) Defect information is stored and used for subsequent analysis. (5) Marking unit and alarm can be activated. (6) Inspection report is prepared and printed.

Digital images are obtained as a high resolution camera scanned through the fabrics product. Image cleaning and modification is carried out for enhancement. Segmentation is then performed and the resultant image is used for analysis. Geometric features are obtained which is then used for pattern matching and classification. **Fuzzy expert system** technique is used and excellent results are obtained. This approach is used in conjunction with a **multilayer feedforward** neural network. In many situations, a defect pattern could be very difficult to detect with one approach but very easy with the alternate approach. Hence, the integrated use of the two soft computing approaches has been very successful. This paper describes how the two approaches are integrated with a careful analysis of images that may be more suitable for one approach but not the other. One significance of this work is that very **fast inspection speed** can be achieved. Also, the speed can vary according to the frequency of occurrence of the defects. The developed system has an accuracy of around 98% in detection of defects. The detection of oil stain has been a very difficult task but our system can also handle such defects.

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Switching Neural Controller for Robust Control of Uncertain Systems: Application to a Chemical Reactor

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ABSTRACT: One of the main difficulties which arise in high performance control of non-linear systems is related to uncertainty about their dynamics. At present, there are only few methods which deal with the non-linear, robust control problem. In this paper a new approach is proposed to design control systems for stabilization of uncertain non-linear plants. The developed approach leads to a more simple structure of the overall controller compared to the methods known in the literature. Thus, it is proposed to synthesize a switching neural controller which includes two controllers: a nominal neural controller and a steady state neural controller. The nominal controller is designed to meet the performance specifications for the mathematical expectation of the uncertain parameters and is used to transfer the system near the set point, while the steady state controller generates the correct steady state values of the control variables and thus guarantees the exact maintenance of the system on the set point. It should be noted that to different values of the uncertain parameters correspond different steady state values of the control variables which will keep the system on the required set point. Here, the capability of neural networks to approximate arbitrary non-linear mappings is used. Thus, design of the nominal neural controller is based on the approximation of the open-loop optimal control obtained by applying Pontryagin's maximum principle, while the steady state neural controller learns the mapping between system trajectory achieved with the nominal controller and the correct steady state values of the control variables. The overall controller is robust in sense that it is able to keep the system on the set point despite of changes of the uncertain parameters. The proposed approach is applied to design robust time-optimal neural controller for a continuous stirred tank chemical reactor. The reactant concentration and the temperature in the reactor are the variables to be controlled, the coolant flowrate is the control variable and the temperature of the feed stream is the uncertain parameter with known probability distribution. Performance of the overall controller is studied and responses corresponding to different initial states and different values of the uncertain parameter are obtained. The closed-loop responses are compared to the open-loop optimal transients obtained in the absence of uncertainty.

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CONTROL OF A FED-BATCH BIO-PROCESS BY USING NEURAL NETWORK OBSERVERS

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ABSTRACT

Bio-technological systems have drawn considerable attention in the last few years due to their very precise industrial applications in various domains. Hence, the control of these processes is a crucial issue in order to ensure reliable procedures and improve productivity.

Fed-batch bio-processes are highly non-linear systems with uncertain parameters. The objective is to control the non-linear plant by a controller of known structure that uses the values of the state variables. However, the dynamic behavior of Bio-process systems is often characterized by state variables for which reliable measurements are difficult to be obtained. In these cases, it is preferable to estimate the state variables. Due to the variation of system parameters, an adaptive observer should be constructed that estimates the unmeasurable states subject to parameter variations. For linear systems, a great variety of design procedures have been developed providing stable and robust adaptation mechanisms, which under certain conditions assure asymptotic convergence of the observation states to those of the plant. However this is not the case for nonlinear systems.

Neural networks offer a promising alternative way of handling this problem. The present paper deals with the production of Saccharomyces cerevisiae, described by a sixth order nonlinear state space model. The control objective is to ensure the process stability and desirable specifications in the presence of disturbances. In the first part the model of the process and its properties are presented. In general the nonlinear state space model is of the form: $x_{k+1} = f(x_k, u_k)$, $y_k = h(x_k, u_k)$. In the second part a non-linear observer is designed by means of an artificial neural network. The observer comprises two neural networks, which in the first place are trained to learn the function mappings $f(\ldots)$ and $h(\ldots)$, respectively. The learning process is equivalent to identifying the system and measurement dynamics. During training the nominal values of the plant parameters are used. It is also assumed that the structure of the system and measurement model are completely known. The objective is to on-line adjust the neural network connection weights, so that given an input vector u_k and the present state vector estimate $\hat{x}_k$ the resulting state estimate $\hat{x}_{k+1}$ leads to minimization of a performance index involving the output error vector **e**. Simulation results are given to show the dynamic behavior of the proposed observer.

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NEURAL CLASSIFICATION OF DANGEROUS SHIPS IN COLLISION SITUATIONS

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ABSTRACT: An increasing traffic of marine crafts on the sea routes has been leading to considerably increasing requirements with respect to both qualifications of deck officers and application of technical arrangements supporting navigator in the process of making decision on a safe manoeuvre under a collision situation. Automatic Radar Plotting Aids (ARPA) equipment is at present the basis for the development of most collision systems. They operate using the analysis of radar signals enabling to track the course and speed of selected objects and the determination of their maximum approach under the situation threatening a collision. The analysis of radar signals is based on the assumption that the kinematics of the objects does not change. Navigator makes a decision on the type of manoeuvre to avoid collision considering the information originated from ARPA system and also basing on his experience and intuition. The latest trends in the development of anti-collision systems concentrate on the constriction of a superior ARPA based systems to determine safe manoeuvre which may be automatically performed after having been accepted by navigator.

This paper describes a solution to the task of classifying risk of collision basing on neural network using simulation computer programmes written in the MATLAB language. A two-layer neural network of a perceptron nature has been described which is able to identify the objects met which threaten to collide with own vessel. Studies have been carried out on collision risk situations the use of two different structures of neural networks.

Conclusions have been formulated which offer opportunities of neural steering of a vessel under risk of collision situations. Neural networks presented in this article may be used elements of the systems applied to assess the safety of passing vessels at sea. They are able to represent heuristic knowledge similar to that demonstrated by an experienced navigator.The correctness of the assessment of the safety of passing vessels with the use of the network depends to a critical degree on the correctness of patterns used in the precess of learning by the network. The use of the knowledge demonstrated by experienced navigators may lead to a situation when the network starts to demonstrate their „averaged" knowledge.

The introduction of an element of an artificial intelligence in a form of an appropriately prepared neural network into the systems of defining safe trajectory of a vessel under a collision situation may accelerate the process of selecting collision avoiding manoeuvre.

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Neural Networks for the model identification of naval turbochargers

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ABSTRACT

The condition monitoring of the machines of a ship is very challenging as the environment is very noisy from the sea waves, their elastic foundations and mainly from the main engines. The problem gets even worse when journal bearings exist, as the housing of the turbocharger, which is founded at the main engine, interacts with the journal bearings and it is very difficult to compute their exact characteristics.

The present work deals with the development of a simple finite element model of the turbocharger which will be connected with a Neural Networks identification algorithm which will increase considerably the accuracy of the model. In this way the automatic diagnosis of potential faults will be possible. The development of this model is based on four sequential steps: the first is the development of a simple but realistic Finite Element model of the whole turbocharger structure using beam elements together with concentrated masses and springs for the modeling of the disks, the enclosure and the journal bearings features. The second step is the monitoring of the real turbocharger at both edges near the journal bearings and on both edges of the turbochargers' foundation at the main engine. The third step is the development of the Neural Network identification algorithm. In ships, being a 'noisy' environment it is extremely difficult to accurately calculate the journal bearings characteristics not to mention several other structural uncertainties. For these reasons all the uncertain features of the model (together with the possible faults) will be identified using Artificial Neural Networks and optimisation methods. An investigation of the computational aspects of identification with Neural Networks will involve several issues related to network size and topology, training patterns and procedures, convergence and sensitivity.

At the final step all the previous steps are combined in such a way that the simple model is fed with the vibrations from the main engine and the Artificial Neural Networks are trying to calculate the uncertain parameters so that the response of the model and the measured ones should be almost identical.

In this way, several possible faults (mass unbalance etc.) can be introduced to the initial model as unknown features of the system so they will be also identified by the Artificial Neural Networks.

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NEURAL NETWORK BASED MAXIMUM POWER CONTROLLER FOR PV SUPPLIED DC SEPARATELY EXCITED MOTOR - A DYNAMIC ANALYSIS

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The PV systems are rapidly expanding finding applications in all corners of electric power technologies. Due to the recent developments in solar technology, reduction in cost of solar cells the application of solar energy receiving considerable attention throughout the world. Particularly in the field of water pumping and irrigation systems in remote areas is coming up where it is not economically viable to connect the existing grid supply.

The purpose of the present paper is to bringout the dynamic analysis of dc motor supplied by the step-up converter with maximum power point controller. The artificial neural network is trained to generate duty ratio for the chopper corresponding to maximum power point in the first step. Subsequently in the second stage the transient analysis of dc separately excited motor with PV supplies is established. PV generator deliver non-linear insolation dependent voltages and energy supplied by the PV generators depends on the operating conditions. To extract maximum power from the PV cell there is a unique operating point for each solar insolation. In order to operate the PV generator at maximum power point a step-up chopper is connected between the PV generator and a d.c motor.

An Artificial Neural Network(ANN) is a network to mimic the performance of biological neural networks. The ANN models are composed of many non-linear computational elements operating in parallel and arranged in different structures to resemble the biological neural networks. The trained neural networks can be used to approximate an arbitrary input - output mapping of a system(system may be static or dynamic). The same ideas can be used for system identification and parameter identification. Hence neural network based methods provide attractive alternative for development of highly efficient adaptive controllers. In our present problem a feed-forward neural network is proposed to adjust the duty ratio of power modulator. The gradient descent algorithm is used to train the neural network. the inputs to the ANN are solar insolation, voltage and current. The output is duty ratio 'δ'. The network has been trained for different solar insolations.

Knowing the duty ratio's that corresponding to maximum power point of PV generator the integrated transient studies were made when the motor is driving a constant torque load. To understand the transient behavior of the system consisting of PV array, step-up chopper, dc motor and mechanical load, the dynamic simulation model is developed to the system. The model is implemented in the continuos dynamic system simulator environment. The transient results are presented for different values of "δ" corresponding to maximum power point at different solar insolation levels. The dynamic analysis of system without max.power tracker is also made and are compared with the results above obtained. It is found that the operation with maximum power tracker will results in better performance even though slight increase in cost.

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Fuzzy and Rule Based Image Enhancement

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ABSTRACT: The two processes of sharpening and smoothing of images are antithetical in that sharpening accentuates noise while smoothing blurs details. The methodology pursued here is to enlarge the image with high quality interpolation so that there are more pixels to process. Edges are broadened as are areas that have small differences between the pixel values. The processing of such larger images with small neighborhoods provides finer control. For example, a 3x3-neighborhood on an image doubled in each direction is conceptually equivalent to a 1.5x1.5 neighborhood on the original, although an actual 1.5x1.5-neighborhood not possible. The enlarged and processed image is then reduced to the original size.

We employ inverse mapping from each pixel location (m,n) of the enlarged (2M)x(2N) image frame to the location (x,y) in the original MxN image. The location (x,y) does not always have integer valued components. We implement a form of fuzzy interpolation with a bell shaped fuzzy set membership function for the linguistic variable CLOSE_TO_(x,y). The result is better quality than the nearest neighbor method and yet is quicker to compute than bilinear approximation. We use the pixel gray level values of the 4 (or 6 or 12) pixel locations nearest to (x,y).

The enlargening and interpolation smooths the image slightly, but we now smooth and sharpen the enlarged image with 3x3 neighborhoods centered on its pixels. For speed and invariance under average gray level of the total image, we take the differences between each neighborhood pixel and the center pixel to obtain $\{\delta_k: k = 1,...,9\}$. The average δ_ave of the differences $\{\delta_k\}$ is computed and a threshold T is used to implement rules on the gray level of the center pixel, denoted *cntr_pxl*, of the form: *IF* ($|\delta\_ave| > T$) *THEN* (*cntr_pxl* = *cntr_pxl* - δ_ave) *ELSE* (*cntr_pxl* = *cntr_pxl* + δ_ave).

If the magnitude of the average difference is sufficiently large, then it is made larger by subtracting this value from the original center pixel value (to sharpen). Otherwise the center pixel value is made more similar to the average value by adding the average difference to *cntr_pxl*. If the center pixel value is a unique minimum or maximum in the neighborhood, it is interpreted as noise and the new center pixel value is put at the average value via *cntr_pxl* = *cntr_pxl* + δ_ave. After this processing, the enlarged image is reduced to the original size using fuzzy interpolation. The enhanced image has sharper edges and smoother regions of similar gray levels. This technique seems fruitful for many applications.

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INTERCONNECTING TECHNIQUES OF DISTRIBUTED MULTIPROCESSOR SYSTEMS IN PROCESS MONITORING APPLICATIONS

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Tool monitoring in manufacturing processes becomes more and more important. Therefore reliable process control systems detecting process abnormalities play an essential role in fully automated machine parks. To gain information about the actual process status the signals of multiple standard sensors, measuring torque, force, feed travels or acoustic emission, are analyzed. During on-line process monitoring a lot of sensor data have to be calculated in real-time and the arithemetic operations for preprocessing, feature extraction and process classification are often complex and need enough computing capability. Distributed processing systems help to overcome this problem, in order that each device executes a special function block. The exchange of data and information between these devices can be performed in several ways e.g. by serial interfaces, dual ported ram or a field bus.

As an example for an worked out and tested application a fuzzy-based process monitoring system which enables the detection and classification of wear performance of the tool and process failures for thread forming processes is described. Actually two processors are present in the system, one for signal preprocessing and feature extraction and the other for fuzzy-classification, interchanging data via dual ported ram. To expand the system with optional devices like a man machine interface or additional data aquisition units it is more convenient to use a fieldbus for the connection of the subsystems and units. This fieldbus has to guarantee real-time data rates without loss of data in a rougth industrial environment. Also the development of special distributed algorithm techniques is required to ensure a uniform system workload.

Fieldbus systems like CAN have some advantages in connecting different embedded control processor systems like the ones in our project. CAN is fast enough, has good data security qualities and becomes almost an industrial standard. It will be shown, that CAN fulfils the required properties.

Of similar importance are intelligent ways to distribute operation blocks of preprocessing and fuzzy based functions to all devices in total system. We are going to present different solutions of connecting processor systems for process control applications, their advantages and disadvantages and show outlooks for our future work

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Fuzzy differential games and optimal guarding — invading a territory strategies

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In most earlier works on differential game problems of guarding a territory, it is generally assumed that each player at time t has perfect information of system state at time t as well as prior to t; thus the game is treated with full information.

To solve this problem, we adopt fuzzy differential game method, i.e. combining fuzzy theory with differential game, to analyze the problem of guarding a territory, and some computer simulation experiments are made.

The territory is a ball with a crisp center point and a fuzzy radius in a plane, and it has energy to attack the invader within the limited range of the outside of its circumference. Thus the end time of game can be shorten and it can bring about a fuzzy payoff.

Each player has imperfect measurement of the location of his opponent. In this case, one player use the polar coordinate(r,ϕ) to measurement is imperfect, the components r and ϕ are both fuzzy numbers with membership function of trianglar or trapezoid fuzzy number, say, μ_r and μ_ϕ, respectively.

According to the fuzzy location of one player and the crisp center point of the territory, we can decide a fuzzy region of optimal final point, the fuzzy region has a special shape consisting of two lines and two curves. we formulate and simulate the two curves, the results testify the two curves are one segment of approximate cardioids that change by following two different radii r_1 and r_2.

Fuzzy logic inference uses Tsukamoto algorithm, using this algorithm, the fuzzy control rules are automatically determined by combining the fuzzy number of the optimal final point region with the membership function of turning angle of movement direction that each player can take. This turning angle is the angle measured from the horizontal axis of the plane centered at the measuring player, then the input and output of the fuzzy controler is the turning angle. Indeed, each player can choose any number of direction as desired, but the scope of direction must be limited, for example, the scope of direction for the invader is limited between 270°and 360°, whereas the scope of direction for the guarder is limited between 0°and 90°.

We make some computer simulation experiments for fuzzy differential game problems of guarding a territory with or without attacking energy, respectively, and compare the two cases with each other. The results demonstrate the former brings about the change of termination set and the end time is shorten. At the same time ,we make a comparison between the fuzzified case and unfuzzified case, the results are radically approached.

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Orthogonal Least Squares based Fuzzy Model for Short Term Load Forecasting

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Accurate short-term load forecasting (STLF) is a challenge to power engineers operating modern Energy Management Systems (EMS). A variety of models for STLF have been reported in the literature during the last few decades. Among them, artificial neural networks and fuzzy systems are currently established as useful and much promising approaches to a variety of power systems engineering problems, with impressive performance in STLF.

This paper presents the development of a fuzzy model for short-term load forecasting. The model employs the Takagi-Sugeno's fuzzy inference system, where the output of a fuzzy rule is a linear combination of the input variables plus a constant term and the output of the fuzzy system is the weighted average of each rule's output. The membership functions are of Gaussian type (bell-shaped). The structure identification of the fuzzy model is performed via the Orthogonal Least Squares method (OLS). The premise part of a fuzzy rule corresponds to a fuzzy hyper-cell.

A two-stage learning algorithm is employed to perform the parameter identification. In the consequent parameter learning stage, the consequent parameters are determined by the use of the Least Squares Estimate. In the premise parameter learning stage, the training task is formulated as a constrained optimization problem, whose objective is twofold: (i) minimization of an error measure, leading to successful approximation of the input/output mapping and (ii) optimization of an additional function, which aims at formulating suitable internal representations and accelerating the learning process. Optimization of the above functions is carried out under the constraints imposed by the fuzzy model construct, which appear in the form of state equations.

Hourly based prediction for the whole year has been performed in order to evaluate the learning and forecasting qualities of the developed fuzzy model. The seasonal and total numbers of parameters are given, leading to the conclusion that the OLS method has provided fuzzy models with a relatively small number of parameters and, consequently, with reduced complexity. The predicted Average Percentage Error (APE) for all days of all seasons, the seasonal and yearly APE's are reported. Additionally, a statistical analysis regarding the difference in the actual and the predicted load is given. The yearly mean absolute forecast error is 91.1 MW and its standard deviation is 77.6 MW.

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An optimum suspension system for vehicles using fuzzy reasoning

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The scope of this paper is to present an optimised semi-active suspension system for ground vehicles, using fuzzy reasoning. The semi-active suspension is constructed by switching the damping forces generated from shock absorbers such that the maximum value of vertical and rotary acceleration of vehicle body at the centre of gravity is minimised from the viewpoint of ride comfort under the constraint on the suspension working space, tyre deflection.

The absorbers are fitted to front and rear axles and the parameters are determined by the time delay between the front and rear wheels. The vehicle system is described by linear differential equations subject to many types of road irregularities. The damping forces at the front and rear shock absorbers are selected from the classified damping forces by the fuzzy reasoning. The suspension travel and its time derivative are treated as the input variables in the fuzzy control rules.

The simulation results indicate that the proposed semi-active suspension is much improved in vertical and rotary acceleration of vehicle body.

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A FUZZY MULTILEVEL DECISION SUPPORT SYSTEM FOR CAR SELECTION[1]

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The selection of a car is a process undertaken by a consumer at least once in his life. The high purchase value and use cost of a car, the wide spectrum of models and types, the existence of a large number of criteria-parameters which must be co-assessed, along with the qualitative nature of a few of these, contribute in the increased difficulty of the decision; furthermore, the offer of quite similar, competitive models, the technological advancements implemented in accessories, the technical completeness, and the marketing strategy of car producers to enrich the equipment, are factors which further clutter the car selection process.

A complete and robust software system has been developed in order to tackle the inherent problems and to effectively assist the consumer in the decision process. The software provides a systematic selection methodology by employing modern, flexible programming and computational tools, and encodes the consumer's preferences/ needs using fuzzy logic principles, thus offering at the same time, an information *and* a decision support tool. The developed system consists of three functional modules: (i) the user-friendly GUI module, implemented in Visual Basic, which accepts the user's preferences in linguistic terms, if needed, and provides the evaluation process results; (ii) a relational database, implemented in Microsoft

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Access, which incorporates technical and economic data, as well as producers and dealers characteristics, for more than 400 car models available today in the greek market; and (iii) the inference engine, implemented in the MATLAB Fuzzy Logic Toolbox, which employs fuzzy logic to encode the user preferences, and to evaluate and rank the car models, subject to the user's criteria. The software system is accompanied by the economic assessment module, which computes the worth present value of the car.

The characteristics, on the other hand, which are used as evaluation criteria, are classified in five groups, each providing a separate evaluation index. These groups are: (i) on-road performance, (ii) chassis properties, (iii) producers'/ dealers' characteristics, (iv) use cost, and (v) total cost. The total number of characteristics is fourteen; some of them are quantitative (e.g. final speed, acceleration, cost, etc.) while others are qualitative (e.g. active safety, quality, etc.). The evaluation of the latter has been performed by incorporating experts' knowledge to ensure objectiveness to the maximum possible extent.

The car selection decision support system has been tested for different user groups, and fine-tuned using experts' assistance. The obtained results demonstrate the reliability and robustness of the system. The complete description of this work is enriched with details on the modeling of the criteria, the evaluation process, and paradigms through a series of screens.

Fuzzy Markov systems for the description and control of population dynamics

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In this paper the model of a nonhomogeneous Markov system with fuzzy transition probabilities and fuzzy input probabilities is proposed. This model can be used for the description of population dynamics, with important applications in manpower and environmental planning. Although, in these real problems the transition matrices and the input vectors are non-exact and have unknown probability distributions, they can be described, by heuristic knowledge, in linguistic terms. Thus, we conclude that the hybrid possibilistic-probabilistic approach is appropriate in this case.

Giving the expected population structure in closed analytic form for a fuzzy Markov system, we study its asymptotic behaviour and find the set of all asymptotically attainable structures. Moreover, the fuzzy input control for maintaining the structure of the system between an upper and a lower bound, is discussed.

The proposed model is provided for the description of biological population dynamics used for the study of the behaviour of a certain population, extending the well-known Leslie model.

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